This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

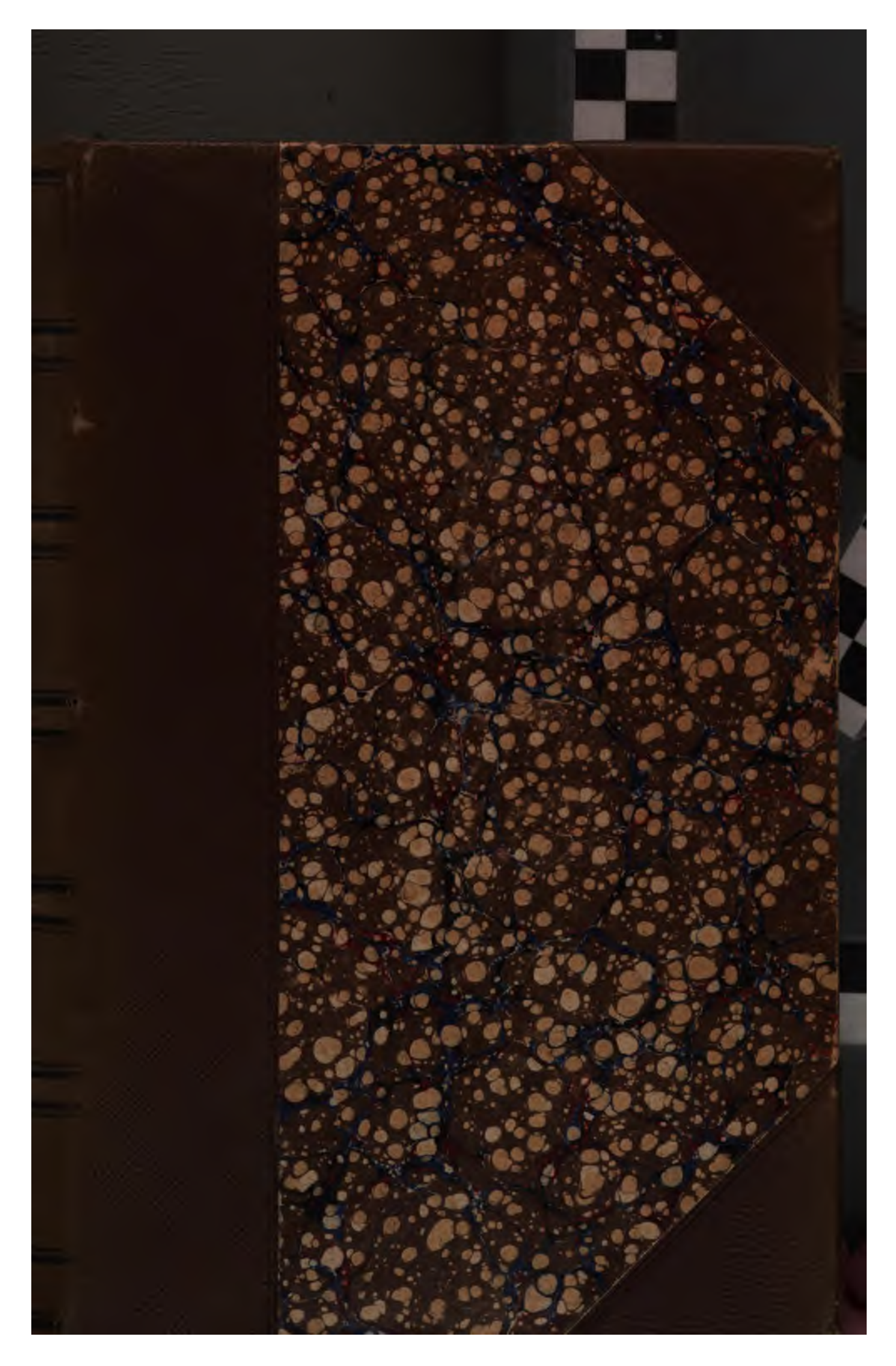
Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.
+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.
+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.
+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

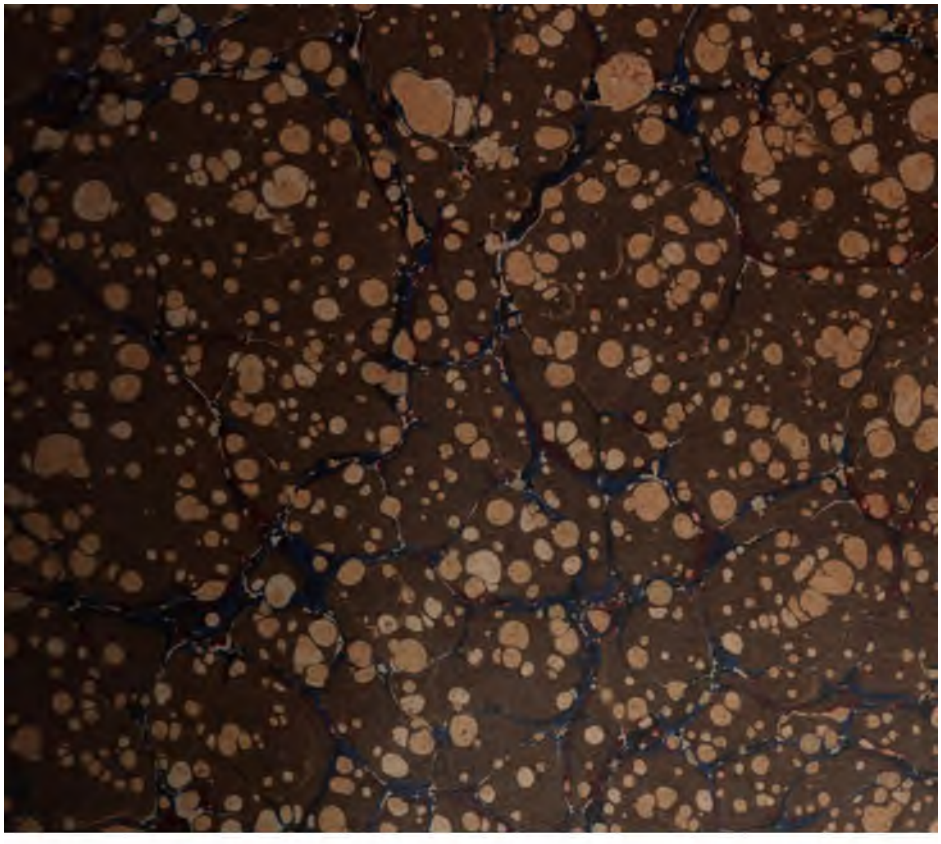
About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`



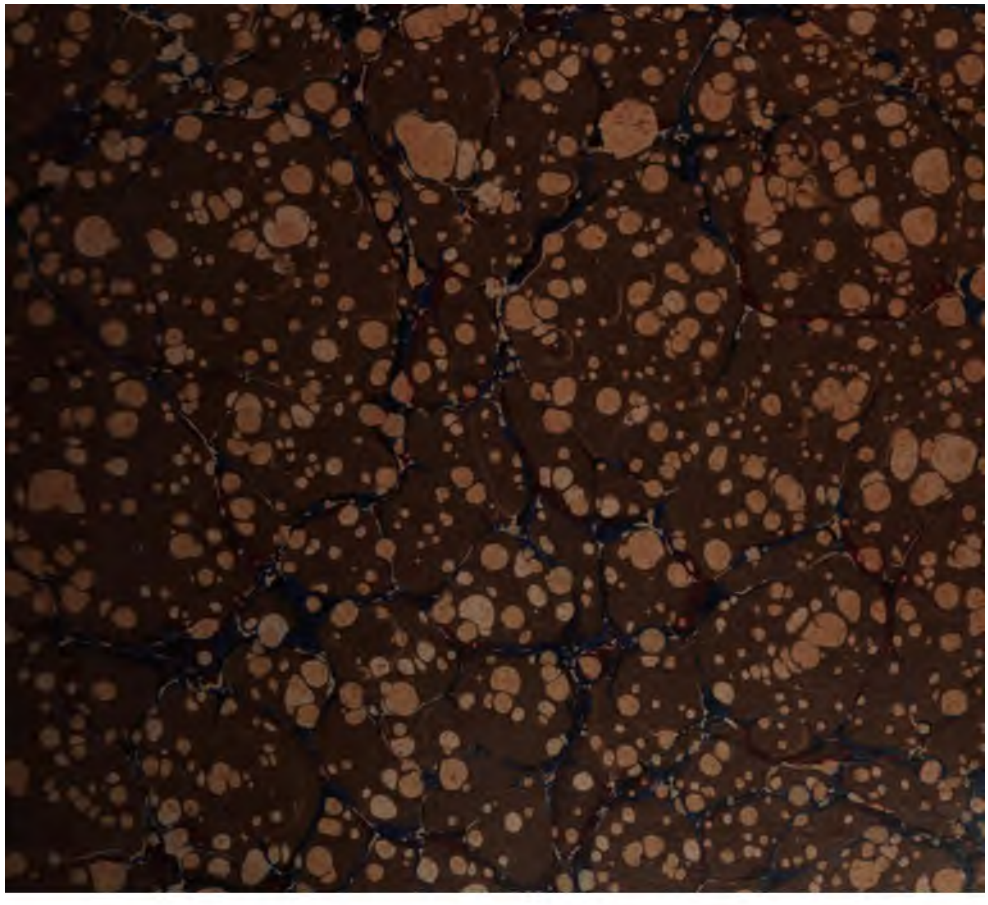
The Branner Geological Library

LELAND·STANFORD·JVNIOR·VNIVERSITY



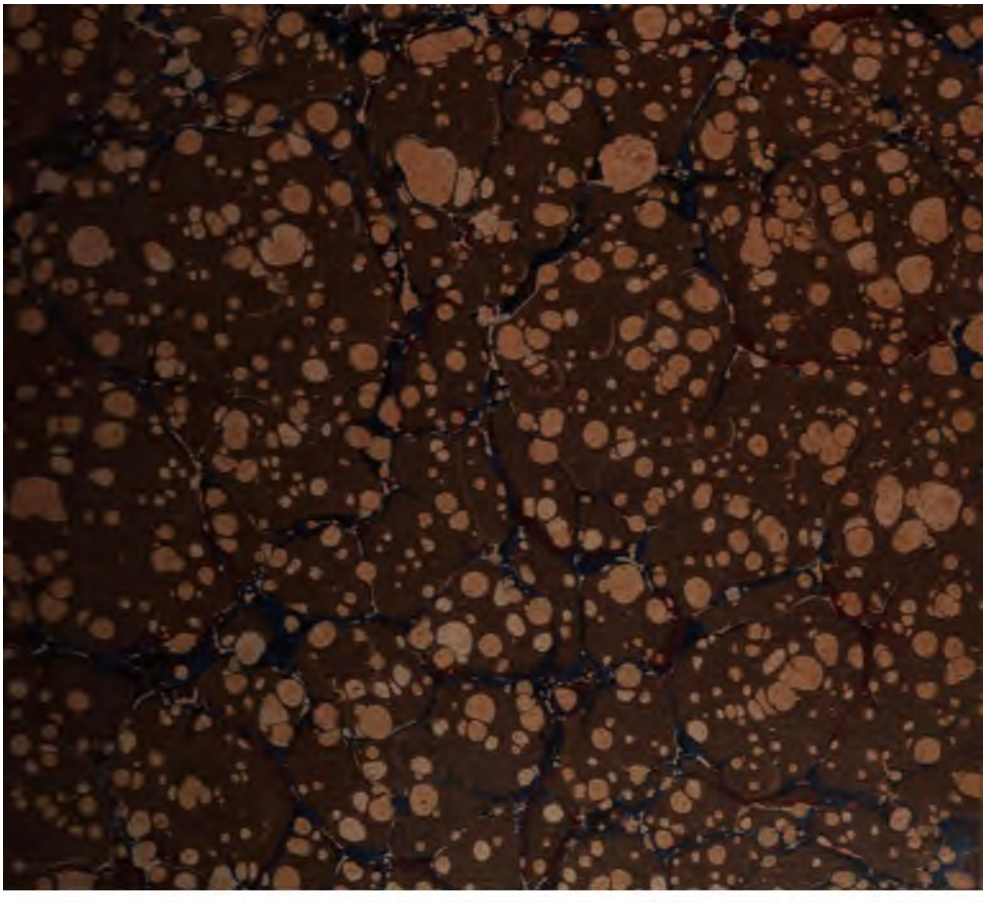
The Branner Geological Library

LELAND·STANFORD·JVNIOR·VNIVERSITY



The Branner Geological Library

LELAND·STANFORD·JVNIOR·VNIVERSITY



A 512

Dr Joseph Leidy
1302 Filbert St

27115

PROCEEDINGS

OF THE

AMERICAN PHILOSOPHICAL SOCIETY.

HELD AT PHILADELPHIA FOR PROMOTING USEFUL KNOWLEDGE.

VOL. XIV. JANUARY TO JUNE, 1874.—5 No. 92.

CONTENTS.

PAGE.

Stated Meeting, January 2, 1874 1
Stated Meeting, January 16, 1874 5
Stated Meeting, February 6, 1874 8
Stated Meeting, February 20, 1874 9
Stated Meeting, March 6, 1874 11
Stated Meeting, March 20, 1874 12
Stated Meeting, April 3, 1874 15
Stated Meeting, April 17, 1874 16
The Brown Hæmatite Ore Banks of Spruce Creek Valley, Pa., by J. P. Lesley. (*With a Map*) 19
Investigation of Iron Ores and Limestones from Lyon, Shorb & Co.'s Ore Banks, by F. A. Genth 84
On a Supposed Allotropic Modification of Phosphorus, by Prof. Edwin J. Houston 108
Abstract of remarks of Prof. Cope, Jan. 16, 1874 110
Origin of Attractive Force, by Prof. Pliny Earle Chase 111
On the Latent Heat of Expansion in connection with the Luminosity of Meteors, etc., by B. V. Marsh 114
On the Plagopterinæ and the Ichthyology of Utah, by E. D. Cope, 120
On the Zoölogy of a Temporary Pool on the Plains of Colorado, by Prof. E. D. Cope 139
Cosmical Thermodynamics, by Prof. P. E. Chase 141
Saving-Fund Life-Insurance, by Pliny Earle Chase 148
A Downward Atmospheric Circulation, as one cause of Extremes of Cold, by Lorin Blodget 150
Meteorological Peculiarities of New England, by Wm. F. Channing, M.D 154
Note on the Color of the Moon, by Persifor Frazer, Jr 155
Note on the Somerset County Coal Beds in Pennsylvania, by John Fulton 157
Cosmical Evolution, by Pliny Earle Chase 159
Electrical Spectra of Metals, by Alex. E. Outerbridge. Communicated by Mr. W. E. Du Bois, U. S. Mint. (*With three Plates*) 162
Stated Meeting, May 1, 1874 174
Stated Meeting, May 15, 1874 176

PROCEEDINGS

OF THE

AMERICAN PHILOSOPHICAL SOCIETY

HELD AT PHILADELPHIA

FOR

PROMOTING USEFUL KNOWLEDGE

Vol. XIV.

JANUARY 1874 TO DECEMBER 1875.

PHILADELPHIA:
PRINTED FOR THE SOCIETY
BY M'CALLA & STAVELY
1876.

213016

PROCEEDINGS

OF THE

AMERICAN PHILOSOPHICAL SOCIETY.

VOL. XIV. 1874. No. 92.

Stated Meeting, January 2d, 1874.

Present, 14 members.

Vice-President, Mr. FRALEY, in the Chair.

A letter announcing the death of Dr. Carl F. Naumann was received from Dr. Ernst Naumann, dated Dresden, Dec. 4th, 1873.

A letter requesting information was received from Capt. J. Herschel, dated 21 Sumner place, Brompton, London, W.

A letter respecting copies of Mr. Henry Dexter's bust of Agassiz was received, dated Cambridge, Dec. 18th, 1873.

A letter requesting the completion of series of the Transactions and Proceedings was received from the Secretary of the K. K. Geologische Reichsanstalt, dated Vienna, Sept. 20th, 1873.

On motion, the request of the Institute was granted, and the missing parts of the series ordered to be sent.

Letters of envoy were received from the Prince Jablonowski Society at Leipsig, dated Aug. 12th, 1873, and from the Department of the Interior at Washington, dated Dec. 22d, 1873.

Donations for the Library were received from the Academia dei Lincei; the Geological Institute at Vienna; the Prince Jablonowski Society; the German Geological Society; the

Revue Politique; London Nature; the Royal Geographical Society; the Nova Scotian Institute; the Boston N. H. Society; Cambridge Museum; Prof. O. C. Marsh; the Connecticut Academy; Commissioners of Fisheries of New Jersey; Penn Monthly; Medical News; Mr. Geo. W. Childs; the U. S. Chief of Engineers; Librarian of Congress; and Wisconsin Historical Society.

The death of Prof. Carl Naumann, at Leipsig, on the 26th November, 1873, was announced.

Prof. Cope stated that the species figured and described by Prof. O. C. Marsh, in a paper received for the Library to-night, under the name of *Brontotherium ingens*, is the one described by himself under the name of *Symborodon trigonoceras*, in the Synopsis of Extinct Vertebrata of Colorado, issued in October, 1873, by the U. S. Geological Survey of the Territories.

Professor Frazer said: "A few meetings ago I referred to the fact that the white color of the moon by day was due to the fact that the dispersed blue light of the sun just supplied the dispersed blue light of the moon, and I suggested that the solar origin of these otherwise missing rays *might be* demonstrated by choosing the first or third quartering of the moon (when lines joining the sun and earth, and the earth and moon, meet nearly at right angles), and regarding the moon through the Nicols prism. As under these circumstances the solar light would be polarized, a change between white and yellow ought to be perceived. The experiment bore out this hypothesis, although, owing to the perfect reflection from suspended particles of greater size than those which reflect the blue light, the color was not a perfect yellow."

Professor Lesley exhibited a recently executed large manuscript map of a hundred square miles of the surface of Centre, Huntingdon, and Blair Counties, in Middle Pennsylvania, with three vertical sections crossing the district—one along the Little Juniata River; another two miles further east, along Warrior Run; and a third five miles further east,

along Half Moon Run. These sections extend across the Valley of Lower Silurian Limestone, with beds of brown hematite iron-ore, and across the bounding mountains of the Middle Silurian Sandstone, Bald Eagle Mountain on the west, and Tussey Mountain on the east, the great anticlinal upthrow of Bellefont being seen in all three sections at the east foot of Bald Eagle Mountain, the Limestones dipping east away from the fault at a uniform dip of about 54°.

He then explained the theoretical difficulties which have hitherto beset the dynamic questions raised by a phenomenon of this kind, an overthrown and faulted anticlinal; especially the question why a dip of just above 54° should follow one side of the fault for many miles, when the rocks on the other side of the fault stood vertical.

This question he thought he had just succeeded in settling by a discovery which resulted from the construction of a fourth section, which he exhibited, extending from the Bald Eagle Mountain westward to the summit of the Alleghany Mountain, taking in the vertical Middle Silurian rocks, the steeply inclined Upper Silurians, the Devonians dipping regularly less and less (from 28° to 8° where observed at different points along the section), and the almost horizontal Lower Coal Measures at the summit of the Alleghany Mountain.

By a system of co-ordinates, the exact curve of the upthrow on the western side of the Great Fault was displayed, using the observed dips along the line of section as elements of construction. The country west of the dip of 15° was assumed to be in its original condition. East of this point, or of the "hypothetical limit of stability," the steeply upturned strata were supposed to slide upon each other with a shearing motion. The basset edges of the vertical strata must be considered as rising in steps above each other westward at the plane of fault, the slope thus obtained facing the east, many thousand feet in the air, over the Bald Eagle Mountain.

On calculating the angle of this slope, which is not a perfect plane, but a slightly curved surface, it turned out to be

an angle of 51° high up, 52° lower down, 53° just over the the mountain, and still steeper where it descended to the present surface of the country, that is, along the line where the vertical rocks are covered by the limestones dipping uniformly about 54°.

It seems impossible to resist the conclusion that this dip of 54° shows that the whole mass of Palæozoic formations on the east, about 20,000 feet thick, rose and rode up the plane formed by the basset edges of the mass upturned vertically on the western side of the fault, and rested thereon at an angle due to the bevel of the western mass, a bevel geometrically determined by the shearing movement among the members of the upcurved western mass.

Mr. Lesley considered the discovery of much importance for structural geology, and that it may prove to be the first real step towards a satisfactory conclusion respecting the slope, or underground (and in the air) angle, of great faults; also proving the negative against a common belief that the great anticlinals of disturbed regions must be reconstructed in air sections as if gaping. It lends great support also to the doctrine of vast erosions, a doctrine taught by Pennsylvanian geologists for many years, and more recently contended for by Jukes, Ramsay, Geikie, and other advanced geologists abroad, on unimpeachable and irresistible evidence.

The report of the Judges and Clerks of the Annual Election was read, by which it appeared that the following officers and members of Council had been elected:

President,

George B. Wood.

Vice-Presidents,

John C. Cresson, Isaac Lea, Frederick Fraley.

Secretaries,

Charles B. Trego, E. Otis Kendall, John L. LeConte, J. P. Lesley.

Councillors to serve three years,

Isaac Hays, Robert E. Rogers, Henry C. Carey, Robert Bridges.

Curators,

Joseph Carson, Hector Tyndale, Charles M. Cresson.

Treasurer,

Charles B. Trego.

Mr. Lesley was nominated Librarian for the ensuing year.

Pending nominations Nos. 740, 741, 742, 743, 744 were read.

And the meeting was adjourned.

Stated Meeting, January 16th, 1874.

Present, 15 members.

Secretary, Prof. Trego, in the Chair.

A letter accepting membership was received from Dr. Franz Joseph Lauth, Prof. Accad. Conservator, dated Munich, Blumenstrasse, No. 2413 rechts, Dec. 16th, 1873 (see printed Proceedings).

Letters of envoy were received from the Greenwich Observatory, Dec. 31st, Royal Institution, Liverpool, Dec. 1st, and the Société Nationale des Sciences Naturelles de Cherbourg, Sept., 1873.

On motion, the last-named society was placed on the list of corresponding societies to receive the Proceedings.

Donations for the Library were announced from the Royal Prussian Academy; the Geographical and Anthropological Societies of Paris; Ecole des Mines; Revue Politique; San Fernando Observatory; National Society of Science at Cherbourg; and Mr. Le Jolis; the Society of Physics at Bordeaux;

R. Astronomical, Geographical, and Antiquarian Societies in London; the editors of Nature; the Geological Society in Glasgow; Boston S. N. H.; Mr. W. E. Dubois; American Academy of A. and S.; American Journal of A. and S.; Prof. F. L. O. Roehrig; American Journal of Pharmacy; Mr. J. W. Nyström; and the Chief of Engineers, U. S. A.

The Committee appointed to draft a minute of the death of Professor Agassiz presented the following report, which was adopted:

The Committee to whom was intrusted the duty of preparing resolutions expressive of the sorrow felt by the members of this Society for the death of their distinguished fellow-member, Louis John Rudolph Agassiz, respectfully report the following minute to be placed upon the records:

In removing the name of Professor Agassiz from its list of living members, the American Philosophical Society loses one of its most valued connections with the active world of science. But this name, transferred to the list of the departed, will always stand upon its records to its honor as an association of men of many nationalities for the promotion of useful knowledge.

Of such men Louis Agassiz was a conspicuous leader, a powerful coadjutor, a genial and inspiring companion. The loss lamented by this Society is keenly felt in every part of Christendom. His investigations have been pursued in so many regions of modern research, that scientific men in all branches sympathize with one another at his death. Great as a Comparative Zoölogist, he was specially unrivaled as an Ichthyologist. He was profoundly versed in the science of the beginnings of life. He was the accepted expositor of glacial phenomena in their geological connections. His collections were made on an unprecedented scale of grandeur, and studied with boundless ardor, wisdom and success. He knew how to induce civilians and legislators to a noble discharge of their obligations to physical science. He knew how to train original investigators in their youth, brighten their hopes, and enliven their aspirations in riper years; tiding them safely over the shoals of literary vanity and scientific ambition, and inspiring them with a loftier enthusiasm for truth itself. Coming to a new world as an Apostle of Original Investigation, every man of science in America sooner or later felt the influence of his presence. He charmed

all by his manners; he endeared himself to all by his frank and genial spirit; he awed the rash and fortified the timid; he bound the leaders together, and gave laws to their followers; he spread the love of nature through classes of society which had been insensible to its influence before; and as he lived, so he died, devising and executing new measures for laying a solid foundation for American science in the heart of the American people. His death is, therefore, a national bereavement.

This Society would tender for the acceptance of the family and intimate friends of Professor Agassiz this solace: the conviction that his fame will stand with that of the great discoverers, investigators, teachers and inspirers of past and future generations, and the assurance which we here express, that, in our belief, no man of science could have lived a more noble and useful life.

Professor Houston communicated a Note on a Supposed Allotropic Modification of Phosphorus. (See Proceedings).

Professor Cope illustrated with drawings and specimens his views of the comparative osteology of the camel and other artiodactyles, living and extinct, and concluded his remarks with a discussion of the Cretaceous age of the lignite and coal formations of the Rocky Mountains. (See Proceedings.)

Dr. LeConte expressed his gratification that his own views of the age of this formation, published some years ago, were now receiving such powerful support.

Mr. Lesley was appointed Librarian for the ensuing year.

The Standing Committees for the year were voted as follows:

Finance,

Messrs. F. Fraley, E. K. Price, and B. V. Marsh.

Publication,

Messrs. Trego, Carson, W. M. Tilghman, H. C. Baird, and C. M. Cresson.

Hall,

Messrs. Tyndale, Hopper, and S. W. Roberts.

Library,

Messrs. Coates, E. K. Price, Carson, Krauth, and Whitman.

On motion, the reading of the list of surviving members was postponed.

Pending nominations Nos. 740, 741, 742, 743, 744 were read, spoken to, and balloted for, and the following declared duly elected members of the Society:

Mr. Joseph M. Wilson, C. E., of Philadelphia.
Dr. Wm. H. Wahl, Sec. Franklin Inst., Philadelphia.
Mr. I. A. Lapham, State Geologist of Wisconsin.
Dr. Hermann Kolbe, of Leipsig, Prof. Chem. University.
Mr. J. E. Wootten, M. E., of Reading, Pa.

And the meeting was adjourned.

Stated Meeting, February 6th, 1874.

Present, 10 members.

Dr. Le Conte, Secretary, in the Chair.

Letters accepting membership were received from Mr. I. A. Lapham, dated Milwaukee, Wis., Jan. 27th, 1874; Mr. Jos. M. Wilson, dated Philadelphia, Jan. 21st, 1874; and Dr. Wm. H. Wahl, dated Philadelphia, Jan. 22d, 1874.

A letter enclosing a photograph was received from Dr. Ed. Jarvis, dated Dorchester, Mass., Jan. 28th, 1874.

Letters of envoy were received from Mrs. Isabella James, dated Cambridge, Mass., Jan. 6th, 1874, and Boston Nat. Hist. Society, dated Boston, Jan. 22d, 1874. (88, 89, 80.)

Donations were received from the R. Academies at Turin and Brussels; the Geographical Society in Paris; the R. Astronomical Society, and London Nature; the Essex Institute; the Museum of Comparative Zoology in Cambridge; Mrs. Isabella James, of Cambridge; the Boston Public Library; Dr. Jarvis, of Dorchester; the American Journal of Arts and Sciences; the American Chemist; American Journal of the Medical Sciences; Med. News and Library

Franklin Institute; American Journal of Pharmacy; Penn Monthly; the Department of the Interior; the California Academy of Natural Sciences; and Prof. S. S. Haldeman.

Prof. Cope offered for publication in the Transactions a paper entitled, "A Supplement to the Extinct Batrachia and Reptilia of North America."

On motion, the paper was referred to a Committee, consisting of Prof. Leidy, Dr. Newberry, and Mr. Lesley.

Dr. Genth communicated some valuable results of recent analyses of limonites and limestones of the Lower Silurian district of Centre, Blair, and Huntingdon Counties, Pennsylvania. (See page 84.)

Mr. Lesley communicated the results of his recent topographical and structural study of the same district.

Prof. Chase developed some views of the relationships existing between the velocity of light waves in ether, and the velocities of the sun and planets, entitled, "A note on the Origin of Attractive force, Identifying the Velocity of Primitive Gravitating Impulse with the Velocity of Light."

New nominations Nos. 745, 746, and 747 were read.

And the meeting was adjourned.

Stated Meeting, February 20th, 1874.

Present, 18 members.

Vice-President, Mr. FRALEY, in the Chair.

Mr. Wootten, a newly elected member, was introduced to the presiding officer, and took his seat.

A letter of envoy was received from the American Institute of Mining Engineers, dated Feb. 12th, 1874.

Donations for the Library were received from the R. Prussian Academy; Revue Politique; London Nature; Mr. A. J. Packard, Jr.; Boston Soc. N. H.; New York Lyceum;

Franklin Institute; American Chemist; American Institute of Mining Engineers; Department of the Interior, U.S.; and Mr. G. R. Crotch, of Cambridge, Eng.

The Committee to which was referred the paper of Prof. Cope, entitled, "Supplement to the Extinct Batrachia," &c., reported in favor of its publication in the Transactions; which, on motion, was so ordered.

The death of Dr. Wm. Proctor, February 10th, at Philadelphia, aged 57, was announced by the Secretary.

Dr. Cresson exhibited the action of Thompson's Calorimeter, and stated the close coincidence of its results with those obtained by trial trips on the Pennsylvania Railroad.

Dr. Cresson exhibited the triangular piece of galvanized iron, once the pinnacle of a cowl on the roof of a building struck with lightning. The point had been melted and elongated upwards and inclined towards an approaching cloud, into which the discharge from the earth through the building took place.

The minutes of the last meeting of the Board of Officers and Members in Council were read.

Pending nominations Nos. 745, 746, 747 were then read.

Mr. Fraley reported that he had received the last quarterly interest on the Michaux legacy, due January 1st, through Drexel and Co.

Mr. Price reminded the Society that half of the interest is appropriated by act of the Society to the planting of the Michaux grove. During 1873 about $300 has been spent in setting out about 100 foreign varieties of oak procured by Prof. Cresson.

Dr. LeConte suggested the future planting of such trees within the Zoological Grounds.

Dr. Horn stated that many of the foreign trees had already succumbed to the attacks of native parasites, two varieties of larvæ having been submitted to his inspection by the Chief of Park Police.

Dr. LeConte, referring to the well known fate of our foreign sycamores and lindens, urged the necessity of plant-

ing trees with the side to the sun which had been so situated in their native sites, and under similar conditions of growth otherwise, so as to reinforce their resisting powers.

Prof. Cope informed the meeting that Prof. Orton's expedition to the Upper Amazon, organized at Vassar College, New York, had returned with copious collections, zoological, botanical, mineralogical and archæological, having reached 17° S. latitude.

The meeting was then adjourned.

Stated Meeting, March 6th, 1874.

Present, 11 members.

Secretary, Prof. KENDALL, in the Chair.

Donations for the Library were reported from the Societies at Moscow, Upsal, Görlitz, Emden, Erfurt, Frankfort on Main, Chemnitz, Bonn, Geneva, Liverpool, Bath, and Madison, Wis.; from the Academies at Berlin, Vienna, Brussels; from the Observatories at St. Petersburg and Upsal; from the Geological Institute at Vienna; School of Mines, and Revue Politique at Paris; Society of Arts and Institutions in Union, Astronomical Society, and Meteorological Office in London, London Nature; Prof. Cooke, of Cambridge; Public Library of New Bedford; Silliman's Journal; Journal of Pharmacy; Penn Monthly, Deaf and Dumb Institute, Hospital for the Insane, House of Refuge in Philadelphia; U. S. War Department; and Mr. George Davidson.

Dr. Allen offered for publication in the Transactions a memoir entitled "Life Forms in Art," with many illustrations, and described the subject and its treatment.

On motion, the paper was referred to a Committee consisting of Mr. Whitman, Prof. P. E. Chase, and Dr. Brinton.

The Secretary exhibited a round bar of cast phosphorus-bronze, left for that purpose in his care by Mr. Hector Orr, who reported it broken under a tensile strain of 63,000 lbs. to the square inch. Its diameter at the place of fracture was slightly diminished.*

Mr. Marsh read a communication, illustrated by diagrams, entitled, "The Luminosity of Meteors due to Latent Heat."

Pending nominations Nos. 745 to 747, and new nominations 748, 749, were read.

And the meeting was adjourned.

Stated Meeting, March 20th, 1874.

Present, 12 members.

Vice-President, Mr. FEALEY, in the Chair.

A letter accepting membership was received from Dr. Hermann Kolbe, dated Leipsig, Feb. 15th, 1874.

Letters acknowledging the receipt of Proceedings were received from Dr. Renard and the Public Museum at Moscow, June 26, 1672, Jan. 1, 1871 (86); Dr. Stralkowski, St. Petersburgh, July 1st, 1872 (86); Prof. A. Braun, Neuschönbron, Berlin, Oct. 12th, 1873 (88, 89); the R. S. Upsal, Nov., 1873 (86, 87, 88, 89); the N. H. S., Emden, Oct. 15, 1873 (88); Prof. Sandberger, Würtzburg, Nov. 12th, 1873 (88, 89); the Münich Observatory, Dr. W. V. Lamont, Dec. 6, 1873 (88, 88); R. Library, Münich, Jos. Aumer, Dec., 1873 (88, 89); R. Soc., Göttengen, Oct. 4th, 1873 (88, 89); N. H. Ass., Bremen, Oct. 31, 1873 (88, 89); Prof. Loomis, N. Haven, March 14th, 1874 (90, 91); N. Y. Hist. Soc., G. H.

* Original diameter of bolt (circular) .75 inch; original area, .4417 in.; reduced area at breaking point, .3067 in.; strain on bolt at breaking, 19,550 lbs. = 63,100 lbs. per square inch. Alloy of tin 10, copper 90, less phosphorus, which is found to give useful properties within the limits of 2.5 and 0.1 per cent.

Moore, March 14th, 1874 (91); and many postal card receipts for 91, the number recently published.

Letters of envoy were received from the R. S., Upsal, Nov., 1873; the I. Acad., Vienna, Oct. 21st, 1873; the R. Library at Münich, Dec., 1873; the S. P. et H. N., Geneva, Sept. 15th, 1873; U. S. Naval Obs., B. F. Sands, Feb. 21st, 1874; C. P. Obs., St. Petersburg, Jan., 1874.

A letter requesting a set of Proceedings was received from the Silesian Society for Fatherland Culture, Breslau, March 5th, 1873.

A letter with three photographic pictures of Indian sculpture was received from Dr. C. H. Stubbs, Wakefield, Pa., purchased by the Society.

"These pictures are taken from the northern face of a rock in the Susquehanna River, near Bald Friar, Md., on which are more than a hundred characters, diagrams, or figures, supposed to have been carved during the stone age. The rock is of quartz, mica, and anthophyllite. Dimensions of figures 12 × 6 and 10 × 6 inches. Photographed in July, 1871. Sets in the Maryland Academy of Science, Lancaster Linnæan Society, and Philadelphia Academy of Natural Sciences."

Donations for the Library were received from the R. Obs., Turin; Mun. Govt. at Linz; R. Acad. and Obs., Münich; J. Acad., Berlin; R. S. Melbourne; Geog. S., Paris; Revue Pol.; London Nature; Mr. W. J. Henwood, Truro; the American Acad., Boston; Franklin Institute; Acad., N. S.; Am. Chemist; Medical News; U. S. N. Obs.; Wisconsin Acad. Sciences; and Minnesota Historical Society.

The death of Charles Sumner, Senator U. S., at Washington, March 12th, aged 63, was announced by the Secretary.

The death of M. C. Quetelet, père, at Brussels, Monday, Feb. 16th, 1873, aged 77, was announced by the Secretary.

Prof. Cope communicated some facts revealed by Lieut. Wheeler's last year's explorations on the 100th meridian, in the valley of the great Colorado, and described some new types of living fish belonging to the fresh-water family of Cyprinidæ, and characterized by a great development of the

predorsal fin spine, a double spine, not co-ossified. Three new types were described, two of them naked of scales, and the third covered only with rudimentary scales.

Prof. Cope communicated a short note entitled, "On the Zoölogy of a Temporary Pool on the Plain of Colorado."

Mr. Blasius, of Philadelphia, present by invitation, exhibited maps and pictures of the tornado of August 22d, 1851, in Cambridge and Medford, Mass., and described his survey and study of the same, the impossibility of applying Redfield's theory except to its central, and Espy's to its ultimate track; for the initial division another explanation was requisite. This led him to the study of the general phenomena attendant upon the meeting of the equatorial and boreal currents, the determination of the shape of land and ocean gales, the use of clouds and their shapes and positions for indicating the nature and position of approaching storms, and the construction of practical sailing directions for vessels in danger.

Mr. Briggs said that he happened to see the tornado referred to, and gave an account of its aspect, effects, and the part of the track which he afterwards examined, by which he was led to the conviction that it was locally determined, like other similar storms, by the low ground of Charles River, heated to an unusually high temperature in a calm day.

Mr. Lesley replied that the constant eastward movement of these tornados, and their sometimes immense length, together with their well known repeated occurrence along the same lines of country, proved them items of an extensive system of physical conditions in the atmosphere on the shifting line of meeting of the equatorial and polar currents, as Mr. Blasius had so well described, and that he hoped the acknowledged defects of the present tornado sailing directions would be corrected by those indicated by the theory of Mr. Blasius.

Pending nominations Nos. 745 to 749, and new nominations 750, 751, were read.

And the meeting was adjourned.

Stated Meeting April, 3d, 1874.

Present, 14 members.

Mr. Eli K. Price in the Chair.

Mr. Snowden, a recently elected member, was presented to the presiding officer, and took his seat.

A letter was received from Samuel V. Summers, M.D., dated New Orleans, March 26th, 1874.

A letter was received from Erastus W. Everson, Sec. and Lib. Un. S. Carolina, acknowledging receipt of Proc. No. 91.

A lithographed letter was received from G. Beck, München, March 22d, respecting Gemminger and Harold's Cat. Coleopteorum.

A letter inviting discussion of J. R. Meyer's doctrine of heat applied to gravity, at the ensuing meeting of the D. N. Versammlung, was received from five commissioners appointed at the last meeting, dated Breslau, March 5th, 1874.

Donations for the Library were received from the Societies at Erlangen and St. Gall; the R. Acad. at Brussels; Paris Geog. Soc. and Revue Politique; London Ast. Soc. and Cobden Club; Essex Institute; Silliman's Journal; Prof. W. P. Trowbridge; New England Soc., N. Y.; Penn Monthly; Am. Jour. Pharmacy; Dr. R. J. Levis; Mr. Isaac Lea; McCalla & Stavely; Maryland Hist. Society; U. S. Dep. of the Interior; University of S. Carolina; Minnesota Academy; N. S.; and Mercantile Lib. Ass., San Francisco.

The Committee to which was referred the memoir of Dr. Allen on Art Forms, reported in favor of its publication in the Transactions.

On motion, the paper was referred to the Publication Committee to report on the propriety of publishing it with its numerous illustrations.

The death of Mr. Joseph Harrison in Philadelphia, March 27, aged 64, was announced by the Secretary, and on motion, Mr. Coleman Sellers was appointed to prepare an obituary notice of the deceased.

Prof. Chase communicated a plan of Life Insurance Companies, which would relieve them of the burden of canvassers.

Dr. LeConte expressed the wishes of the officers of the U. S. Mint to have the council and advice of men of science as to the best device for a commemorative medal of Agassiz.

The subject was, on motion, referred to Dr. LeConte, Dr. Wilcox, and Mr. Fairman Rogers.

Prof. Haldeman exhibited a coin of Sumatra, found in a bag of coffee in Philadelphia. On one side was the legend, "Island of Sumatra, 1804," on the other, in Malay, "sa teng wang," one-half piece, and used it to illustrate the difficulties encountered by decipherers, and the methods of overcoming them. The coin he gave to the Museum of the Mint.

Prof. Houston exhibited specimens of an apparently igneous rock from the banks of the Schuylkill, above the Serpentine quarries.

Pending nominations No. 745 to 752 were read.

And the meeting was adjourned.

Stated Meeting, April 17th, 1874.

Present, 14 members.

Vice-President, Mr. FRALEY, in the Chair.

Mr. Wilson, a lately elected member of the Society, was presented to the presiding officer, and took his seat.

A letter was received from Mr. Coleman Sellers, accepting his appointment to prepare an obituary notice of the late Mr. Joseph Harrison.

Letters of acknowledgment for No. 92 of the Proceedings were received from the New York Lyceum and Salem Institute.

Letters of envoy were received from the Royal Saxon Society, dated Leipsig, November 18th and 29th, 1873.

Donations for the Library were received from the R. Asiatic Society of Japan, at Yokohama; the Royal Academies at Copenhagen, Berlin, Leipsig, Göttengen; the Societies at Basil, Salem, Montreal; the Royal Bavarian Library, the Revue Politique; and London Nature; the London Royal S. Meteorological Committee; Geographical, Chemical, and Zoölogical Societies; Amherst College; State Geologist of New Jersey; Franklin Institute; American Journal of the Medical Sciences; Medical News and Library; American Pharmaceutical Society; Prof. E. D. Cope; U. S. Department of the Interior; and Prof J. Lawrence Smith.

The R. Asiatic Society of Japan, at Yokohama, was ordered to be placed on the list of correspondents to receive the Proceedings.

The Committee to which was referred the subject of a proper device for the Agassiz medal, reported through Dr. LeConte that they had considered the subject, and suggested a device to the officers of the U. S. Mint.

At Prof. Cope's request, the Secretary exhibited parts of a scull of *Eobasileus galeatus*, one of several specimens obtained by Prof. Cope last year, on the Bitter Creek, Wyoming. The posterior wall of the cranium is in this specimen very perfect, and retains one of its horns. The two middle pair of horns were in separate fragments, as also the two nasal horn-cores.

A walrus fossil cranium from Accomac Harbor, in Virginia, was also exhibited. The fragment was about nine inches long. Three well-worn teeth remained in their sockets on the side, and two on the other; one socket was vacant on one side, and two on the other. The front margin of the roof of the mouth was perfect, and both sockets for the tusks. The nasal cavities, separated behind and united in front with the partition, were well shown. The fragment terminated with the front wall of the brain cavity. The whole was thoroughly fossilized.

This is the most southern specimen of walrus yet discovered on the Atlantic coast, and must have been washed

ashore from glacial drift bedded beneath the actual sea sands of the Virginia coast. A specimen in the Museum of the Academy of Natural Sciences, at Philadelphia, was found much further north, on the New Jersey shore. The discovery of fossil walrus in Virginia is important, as indicating the extension of the drift deposits further southward than was supposed.

Prof. Chase read a note relative to Meyer's theory of heat in its application to theories of gravitation, and explained the present attitude of the discussion.

Prof. Fraser explained a possible improved method of notation for classifying organic compounds in chemistry, taking the compounds of carbon as a theme for illustration.

Pending nominations Nos. 745, to 752 were read, spoken to, and balloted for, and on scrutiny of the ballot-boxes the following were declared to be duly elected members of the Society:

Dr. William Camac, of Philadelphia.

Mr. John Coates Brown, of Philadelphia.

Mr. Frank Thomson, of Altoona, Pa.

Rev. Robert Ellis Thompson, of the University of Pennsylvania.

Mr. J. Norman Lockyer, of England.

Mr. Richard A. Proctor, of England.

Mr. Raphael Pumpelly, State Geologist of Missouri.

Prof. Charles A. Young, of Dartmouth College, Hanover, New Hampshire.

And the meeting was adjourned.

The Brown Hematite Ore Banks of Spruce Creek, Warrior's Mark Run, and Half Moon Run, in Huntingdon and Centre Counties, Pennsylvania, along the line of the Lewisburg, Centre County and Tyrone Railroad.

By J. P. Lesley, Professor Geology, University of Penna.

(*Read before the American Philosophical Society, Jan.* 2 *and Feb.*6, 1874.)

Preliminary Chapter.

The district under examination, with an area of about one hundred square miles, is bounded on the west by the Bald Eagle Mountain, on the east by Tussey Mountain, and on the south by the Little Juniata River, and the Pennsylvania Central Railroad.

The Huntingdon-Centre County-line crosses it transversely from mountain to mountain. The Huntingdon-Blair County-line follows the river.

Spruce Creek flows southward along the foot of Tussey Mountain. Its branches, Warrior's Mark Run and Half Moon Run, cross the country from Bald Eagle Mountain, along the foot of which their head waters flow. Logan's Run flows at the foot of Bald Eagle Mountain into the Little Juniata River near Tyrone. See large Map.

The river and the two runs afford fine opportunities for three cross-sections, represented in figs. 1, 2 and 3. These sections have been photo-lithographed (like the map) to a very reduced scale for convenience of publication, but were carefully constructed on the same vertical and horizontal large scale, so that their geology may be relied on.

The map was plotted with great care from the survey notes of Mr. Franklin Platt,* (as were also all the reduced local maps of the Ore Banks, figs. 8 to 44) and adjusted with almost no variation to the railroad survey maps in the office of that experienced and most reliable Civil Engineer, Mr. Leuffer, who located, constructed and has in charge the completion of the L. C. C. and T. R. R., to whose courtesy I am in this as in other cases, so largely and gladly indebted.

The map is drawn in ten foot contour lines, determined by aneroid observations, based on the spirit levels of the railway lines, preliminary and adopted. One set of aneroid observations was carried to the top of Tussey from Pennsylvania Furnace; the rest of the mountain being drawn in by rough trigonometrical observations from the Spruce Creek road. The gaps in its terrace are all properly placed and their characteristic features given: but slight variations in the almost dead level crest of the mountain could only be indicated. The survey of the Spruce Creek Valley was made rapidly and only for the purpose of assigning a proper value to its topographical features, a new township survey by a corps of odometer surveyors being the basis. Here a considerable adjustment had to be made, which renders this part of the map of no authority, as against

*Formerly an Assistant on the U. S. Coast Survey.

careful future surveys. The adjustment affects the whole southeast corner of the map, viz.: the interval between the mouth of Warrior's Run and the river. It is none of it accurate. The rest of the map is very accurate and reliable.

Various former surveys of the Juniata were compared in plotting Mr. Platt's survey along the Pennsylvania Railroad, and all were found to be discordant in details, but the topographical features of the deeply eroded bed of the Little Juniata are portrayed with sufficient precision.

Time failed for a careful survey of the mouths of Canoe and Sinking Valleys south of the river. I leave these and the interesting synclinal mountain (Canoe Mountain) which separates them, for a future opportunity. Canoe Valley leads south into Morrison's Cove, a reconnoissance survey of which I made some years ago for the Pennsylvania R. R. Co., to determine the economical value and geological attitude of its brown hematite iron ores, the analogues of those to be described in this report.

Three sets of aneroid levels were carried to the top of the Bald Eagle Mountain, and two of these were continued to its western base, along which flows the Big and Little Bald Eagle Creeks, and runs the Bald Eagle (Tyrone, Bellefonte and Lockhaven) Railroad. A much more careful study of Bald Eagle Mountain than of Tussey Mountain had to be made; first, on account of the Great (Bellefonte or Tyrone Forge) Fault which runs along its east foot; secondly, on account of the vertical attitude of its rocks and the very irregular erosion to which it has therefore yielded; thirdly, on account of a deflection of trend, due to the little synclinal crimple shown in two of the Cross Sections; and fourthly, on account of the outcrops of fossil ore on its western slope. Yet, I should be glad to make a complete hypsometric projection of this very interesting mountain, with its dentated double crest, for scientific purposes. Its character is, however, well portrayed in my map and will tell the whole story to any geologist.

A second map (also reduced by photolithography from its original scale of 100 perches to the inch,) is appended to this report. It is a copy, corrected to date, of the land line map* of Lyon, Shorb & Co.'s ore and other lands in Huntingdon, Blair and Centre Counties, covering about 200,000 acres in the valley and on its two bounding mountains, and stretching westward beyond the Bald Eagle Creek to the coal measures on the crest of the Alleghany Mountain. It was impossible to transfer the numerous and complicated land lines of this map to my topographical map without concealing its features beneath a net work of irrelevant indications. I have gone even farther in my anxiety to show with unobstructed clearness the geology by the topography; I have abstained from introducing *local names* upon my map, trusting to the intelligence of those who consult it, guided by a small key map in its southeast corner, and by the descriptions I give of localities with reference to the numerous ore banks which are *numbered*. The key to the numbers will be found in the northeast corner

* The original is in the office of Mr. Lowrie, at Warrior's Creek, Huntingdon Co., Pa.

FIG. 1.

A Structural Interpretation
of the dips exposed along the
Little Juniata River and Pennsylvania Railway
between Bald Eagle and Tussey Mountains,
in Blair & Huntingdon Cos. Penna.
By J. P. Lesley and Franklin Platt.
Philadelphia 1873.
Tyrone City
Scale of miles
Middle Silurian
Sinking Valley anticlinal.
Canoe Valley anticlinal.
Canoe Mountain Synclinal
Spruce Cr.
Crest of Tussey Mountain
S.E.
Notes.
1. I read the 50° and 90° dips as overthrown, but not the 48° (see Jackson, in Rogers' Final Report, Vol. I. p. 50) because of a similar structure 2½ miles further east, for which see section through Huntingdon Furnace.
2. The dip of 48° and the riding up of the Limestones over the ends of the Potsdam City rocks, with the slant of the Great Fault is demonstrated by the Bald Eagle Furnace and Allegheny Mountain section.

of the map. The numbers follow rudely the ore belts, but not on any strictly scientific principle; they are arranged for the convenience of the reader.

A third map, heliotyped from a large original study of Brush Mountain (Bald Eagle Mountain continued southward across the Little Juniata River) is also appended, to show the outcrop of the Fossil Ore on that part of the property which extends in that direction. But the description of these Upper Silurian Fossil Ores must be kept separate from my discussion of the Lower Silurian Brown Hematites, or Limonites of the Nittany Valley.

GENERAL GEOLOGICAL CONSIDERATIONS.

The country specially examined in this report covers outcrops of the following geological formations, designated by the numbers of the old Pennsylvania State Survey, and the names given them by English and by New York Geologists.

No. V.	Upper Silurian.	Clinton Red Shale.
No. IV.	Upper, white. Middle, red, Lower, grey.	Medina Sandstone.
		Oneida Conglomerate.
No. III.	Lower Silurian.	Hudson River Slate.
No. II.	Lower Silurian.	Trenton Limestone.
		Black River Limestone.
		Birdseye Limestone.
		Chazy Limestone.
		Calciferous Sandstone.
No. I.	Lower Silurian.	Potsdam Sandstone.

The Iron ore horisons described in this report are as follows:

In No. V. The upper or soft fossil ores.
The lower or hard fossil ore.

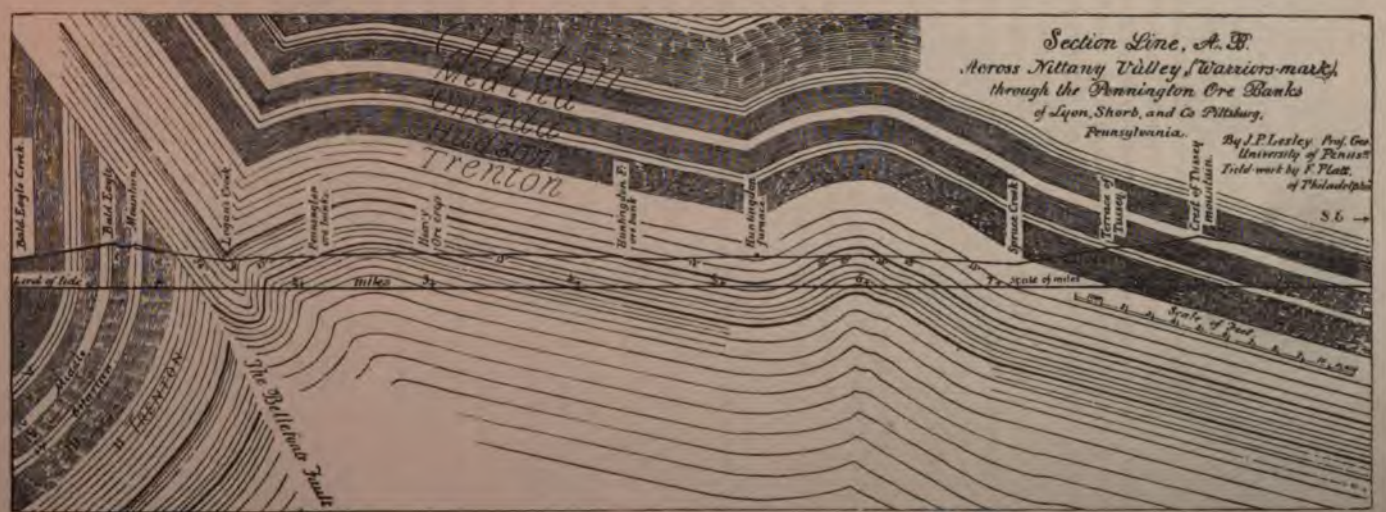
In No. II. The first horison at the bottom of the Trenton Limestone: Pennsylvania Furnace and Spruce Creek ores, and ores of Cale Hollow.

In No. II. The second horison: the whole Dry Hollow Range of ore banks, including Huntingdon Furnace and Dorsey Bank.

In No. II. The lowest horison, far above the top of the Calciferous: the Warrior's Mark and Lovetown Range and the Pennington Range.

The dip of the rock, of the whole country exhibited on the map, from the foot of Bald Eagle Mountain to the crest of Tussey, is towards the S. S. E., with one or two undulations of no great moment. This is plainly shown by the three cross sections, figs. 1, 2, 3.

FIG. 2.


Section Line, A. B.
Across Nittany Valley, (Warriors-mark),
through the Pennington Ore Banks
of Lyon, Shorb, and Co Pittsburg,
Pennsylvania.
By J. P. Lesley Prof. Geo.
University of Penns.
Field-work by F. Platt,
of Philadelphia
Clinton
Medina
Oneida
Hudson
Trenton
Bald Eagle Creek
Bald Eagle Mountain
Logan's Creek
Pennington ore banks
Harry Ore crop
Huntingdon F. ore bank
Huntingdon furnace
Spruce Creek
Terrace of Tussey
Crest of Tussey mountain
Level of tide
miles
To scale of miles
Scale of feet
The Bellefonte Fault

A great fault runs along the foot of Bald Eagle Mountain, and on the west side of this fault the same formations are seen descending vertically. They then curve sharply, and pass horizontally N. Northwestward under the Alleghany Mountains, as shown in diagram section fig. 4.

This diagram section is constructed from the dips of the Upper Silurian, Devonian and Coal Measure rocks, observed on a survey of the road from Bald Eagle Furnace up Emigh's run and Laurel Creek to the crest of the Alleghany Mountain. The measurement of the curves of the different layers of this upturned mass, taken at every thousand feet, as shown in the diagram, result in giving a slope of 50° to 54° to the bassett edges of the broken mass.

It is evident that the upslide of the other section of the broken mass has conformed to this slope, and that the uniform dip of 54° ± observable for miles along the S. S. East foot of Bald Eagle Mountain (as represented in Juniata Section, and Sections AB and CD) is perfectly explained by the diagram.

This is the first time, I believe, a solution of this difficult problem in structural geology has been reached; and its bearings upon similar phenomena attending upthrow-faults and broken anticlinals in other regions will be noticed by geologists.

The theoretical deductions from this solution are important.

It proves that the original fault was in a vertical plane, and not on a slant.

It proves that the lower Silurian Limestone mass has ridden upon this slope to a considerable height, probably several miles, in the air above the present surface.

It illustrates the great erosion of the country, amounting to *thousands of cubic miles* of earth crust, including the coal measures (which are preserved on Broad Top, 20 miles to the southeast,) and gives us the source of the Cretaceous and Tertiary deposits of New Jersey and Delaware.

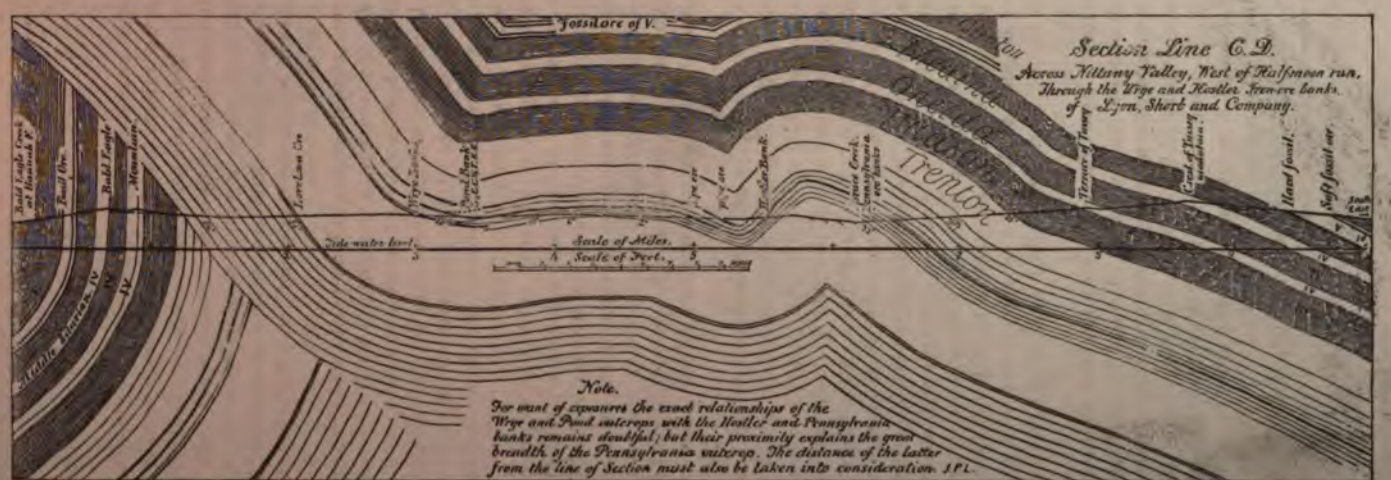
It leads me even to suspect the existence of a subterranean range of Laurentian Mountains (with their usual magnetic iron ores) at the bottom of the fault; this range determining the line of fracture.

It accounts for the general S. S. E. dip across the whole valley, Tussey Mountain, and as far as Huntingdon.

It assures us that the brown hematite ore beds of the district studied in this report belong to rocks of different ages, and are ranged in parallel belts according as the formations which carry them descend successively (S. S. Eastward,) beneath the present surface.

It confirms the opinion that the quantity of ore in these belts is not a local accident at each of the ore banks, but bears a fixed relation and proportion to the outcrop run of the ore-bearing limestones, lengthwise of the valley; and, therefore, that any estimate of the quantity of ore we may make by examining the diggings, must fall short of the actual quantity of ore to be mined in future years in this valley.

FIG. 3.


Section Line C.D.
Across Nittany Valley, West of Halfmoon run,
Through the Wrye and Hostler Iron-ore banks,
of Lyon, Sherb and Company.
Fossil ore of V.
Trenton
Hard fossil.
Soft fossil ore.
Scale of Miles.
Scale of Feet.
Note.
For want of exposures the exact relationships of the
Wrye and Pond outcrops with the Hostler and Pennsylvania
banks remains doubtful; but their proximity explains the great
breadth of the Pennsylvania outcrop. The distance of the latter
from the line of Section must also be taken into consideration. J.P.L.

The *original source* of the brown hematite iron ores of our Lower Silurian limestone valleys has been speculatively sought for without sufficient investigation in the field; and much practical mischief has resulted from the errors promulgated. Most persons have looked upon them as accidental and local inwashes from unknown sites. Some have more systematically defined them as a residual precipitate from the disseminated iron-sand grains of the surrounding Middle Silurian mountain rocks during their erosion.

All such vague speculations might have been avoided had the results of Dr. R. M. S. Jackson's survey of the Nittany Valley ore beds in 1838 or 1839 been published by himself. As assistant on the geological survey of Pennsylvania he obtained the data necessary for concluding, at that early day, that they were deposits *in loco originali*, of the iron (as hydrated peroxide) set free from the limestone or dolomite rocks during their gradual erosion and dissolution.

I have myself, during the last twenty years, had ample opportunities for arriving independently at the same conclusion; and an intelligent study and comparison of the aspects of the ores and rocks in our iron ore banks will, I think, satisfy any good geologist in the same sense.

The precise *modus operandi* of the process is not yet well understood; for it involves chemical considerations not thoroughly worked out. But a general statement of the operation can be made without risk of serious error.

The rocks of the Lower Silurian Age were originally sea-muds, composed of rounded grains of dolomite (derived from previously existing Laurentian Land), cemented together with a paste of carbonate of lime. Some of the beds consisted also of rounded grains of quartz. Some of the layers were nearly pure carbonate of lime. All contained a larger or smaller percentage of iron, lead, zinc and other metals, precipitated either chemically, or by the agency of organic beings, from the solutions of their carbonates, chlorides, &c., in the river-and sea-waters. The orderly explanation of all the chemical and organic features of this complicated operation is still to be given to the scientific world. But all will agree that the general character of the calcareo-ferruginous muds, the sediments of that early geological age must have been much as above described.

During the long Upper Silurian, Devonian and Carbiniferous Ages, these Lower Silurian sediments were buried to a depth of over 16,000 feet, beneath the later sediments. They remained wet. Their great depth raised their temperature $16,000 \div 50 = 320^\circ$ Farenheit's thermometer; which added to the mean temperature of the surface, would keep them under the influence of a moist heat of nearly 400° F. through what to man is a small eternity of time.

Dr. Genth's discovery of the amorphous or gelatinous condition of a part of their silica is thus explainable. Varied reactions must have ensued. The carbonates of lime and magnesia combined as dolomites,

FIG. 4.

A geological Section across Bald Eagle Valley in Pennsylvania;
with a Geometrical Protraction of the Dips increasing Eastward;
showing how the bevelled edges of the Upper Silurian determine
the Lower Silurian Dip of 54°
in Nittany Valley.
Allegheny Mountain.
Lowest Coal Bed.
Conglomerate XII.
Red Shale. XI.
X. Sandstone
grey sandstone
IX. Red sandstone
Cattskill
Level of Tide-water
VIII. Olive Slates
with dark layers
Cattskill
Chemung
VIII. Dove colored Sandstones and Olive Slates
Portage
VIII. Black and Purple Slates and Shales.
VIII. Black Slates.
VII. Oriskany Sandstone
VI. Lower Helderberg Limestone
Genesee.
Hamilton
Note.
The lines in the diagram, showing the curves of the uplift, merely carry the observed dips; they do not define top & bottom limits of Formations.
Scale before Photo-lith: reduction—1000 feet to 1 inch.
V. Clinton.
Medina.
Empirical Limit of Stability
Upper Silurian shales
Middle Silurian
Hudson river slates. III.
Lower Silurian Limes: II.
Lower Silurian Limestones: II.
J. P. Lesley 1873

which in part crystallized in rhombohedral crystals, the forms of which we now see, in the outcrops, emptied by dissolution. The silica hardened (without crystallizing) around these rhombs, so that we see the same cavities in it. The iron became peroxydised as *fibrous* hematite and the silica can be obtained by dilute nitric acid also *in the same fibrous form.* All this points to the first formation of the iron ore while the rocks were still at a great depth, wet and soft and warm.

But at the end of the coal era the Middle States rose from the waves and have never been covered by the ocean since that time. The edges of the Bellefonte Fault stood as a mountain range as high as the Alps (see Fig. 4), and the backs of some of the great anticlinals of Pennsylvania must have formed plateaus then as high as Thibet and Bootan are now.

FIG. 5.

Erosion commenced and has continued through the Permian, Jurassic, Cretaceous and Tertiary Ages to the present day, and still goes on. The high plateau was gradually worn down to the present surface. Mountains once 30,000 or 40,000 feet high are now but 2,000 or 3,000 above sea level. The valleys were excavated as the mountains lowered, and the outcrops of the Lower Silurian limestones of Nittany Valley are but 800 to 1300 feet above tide (see the contour lines of the map).

This slow erosion gives us the second part of our explanation of the brown hematite iron ores. It explains the innumerable caverns and sink holes and dry hollows of this Nittany and other limestone valleys. It leads us to expect to find traces of such caverns and widened fissures and sink holes of the last preceding age, filled up with a wash of clay, sand, and iron ore from outcrops lately existing not far above the outcrops which run along the present surface.

The erosion now still going on, and the special activity of the last

or glacial age, may very well explain that outspread of surface wash-ore which makes so large a feature of the case. It may also explain the corrugations of the clay and ore strata in these superficial wash-ore deposits as represented in Figures 5, 6, 7; the localities pictured being on the line of the railroad near the East Pennington Ore Banks.

Thus the different theories in vogue among our iron men are harmonised. Each theory has its own basis of truth, its own set of facts, but does not embrace all the phenomena.

Those who contend that the brown hematites lie in pockets are correct; but they must confine the assertion to that part of the ore which now occupies former caverns and fissures and sink-holes.

Those who contend that the brown hematites are surface washes caught by the accidental variations of the earth's surface, are correct; but they

Fig. 6.

Summit Cut, in siena-colored Wash-Ore, exhibiting erosion (?) & débris of pulverized Calcif. S. S.

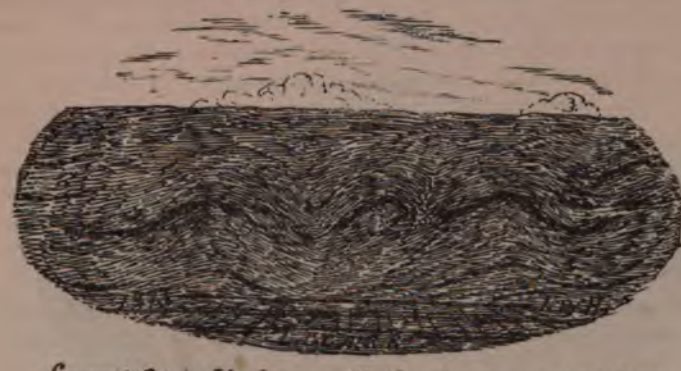
must limit the application of their theory to banks which show rolled gravel and rolled ore, and a confused and mingled mass of ore and sand and clay.

A third view is equally correct and much more important. It must be accepted as probable, that in spite of later movements, and in addition to cavern-deposit ores, and surface-wash ores, there are interstratified beds of brown hematite, still in their original places, although not in their original condition, descending with the general slope of the formations between undissolved limestone, dolomite and sandstone rocks to undetermined depths, and ranging lengthwise of the district, so that rows of ore-banks can be and have been opened in continuous belts of

many miles length, and on continuous outcrops of ore ground of every conceivable variety of character, quality and quantity.

It is provable by reference to sections Figures 1, 2, 3, and other illustrative drawings in this report, that there exists several of these belts; representing different *geological horisons;* and due to an extra charge of iron given, we know not how, to sediments of different ages. As, on a grand scale iron-bearing rocks occur at various stages of the column of palæozoic rocks from No. I, Potsdam S. S., to No. XII, Coal Measures, —so, within the narrower limits of one subdivision of this column, viz., in the Lower Silurian system, iron bearing rocks occur at various stages, separated by from 500 to 2000 feet. These have already been stated.

FIG. 7.



Summit Cut in Washore with Ore-streaks One foot thick.

The measurements will be given in my Detailed Description of the Ore Banks, and no repetition of them is here necessary.* I will only give in tabular form the thickness of the Lower Silurian Limestone formation so far as visible and as measured along Warrior's Mark Run :—

	feet.
Hudson River Slates.....	
Trenton Limestone, &c.....	2500
Pennsylvania Furnace and Cale Hollow Ore Banks :	
Interval of Limestones.....	700
Huntingdon Furnace Ore Banks :	
Interval of Limestones.....	550
Pipe-ore Range near Toll-gate :	
Interval of Limestones.....	1500
Pennington, Town, Lovetown Banks :	
Interval of Limestones.....	3000
The edge of the Fault stops further measurement downwards :	——
Total visible thickness of Limestones.....	7750

* See No. 31, Huntingdon Furnace Banks.

Practical Value of the Ores.

The experience of sixty years has demonstrated the exact values of the brown hematite iron ores of all the Lower Silurian Valleys of Pennsylvania: on the Lehigh; in the Great or Cumberland Valley; in Kishicoquilis Valley; in Morrison's Cove, Canoe and Nittany Valleys.

The general resemblance of ores from all the Banks is striking. The local variations are still more striking. The key to those variations was only got when the true geological theory of structure was studied out. But it is still a perplexing question why red-short, cold-short and neutral ores should lie so near each other. There is scarcely an ore bank in Pennsylvania in which the chemist will not find some infusion of sulphur and phosphorus. But some ores have been so slightly charged with one or other, or both of these elements, that they rank in the first class.

Others are so heavily charged, that they are useless for Bessemer work; take a low rank as anthracite or coke iron ores; and only make good pig-metal when smelted in small quantities, with charcoal and a feeble cold-blast.

This is especially true of those of the lowest geological horison or oldest in age, belonging to rocks of Pitsdam age, rocks which rise upon the flanks of the South Mountain. Fortunately, these ores nowhere reach the surface in Nittany Valley, being buried in the jaws of the Bellefonte Fault. Even the Pennington horison is too high for these ores.

The consequence is, that most of the ores of the district under notice here yield a practically neutral ore and make the best possible iron in cold blast charcoal furnaces, and good iron with the hot blast, and mineral fuel. The appended analyses of Dr. Genth will make this fact evident.

Phosphorus, however, is found in all known Silurian Brown Hematite ores (with some rare exceptions) in quantity enough to prevent the manufacture of steel. But in some cases mixture with other ores will rectify the ore. In other respects the per centage of phosphorus is too small to do hurt. Dr. Genth's analyses will give the figures in this case also.

The reputation of Pennsylvania iron was greatly made at Pennsylvania Furnace. Its quality could not be surpassed. Neither the older Swedish, nor the best English, when English iron was still good, nor the more recent magnetite pig-metal of Lake Champlain and Missouri, have excelled it; and it shared this reputation with furnaces smelting similar ores.

There are parts of the deposit in almost every Bank, which are sandy and lean. These have been hitherto fastidiously rejected by the charcoal coal blast furnaces of the district. Such ores are, however, in demand for our anthracite and coke furnaces, and the ever-increasing market for them will require the mining of the whole. I believe that carefully selected ore from these banks will even furnish iron fit for Bessemer use.

Probable Quantity of Ore.

Estimates of the quantity of Brown Hematite Ores are among the most uncertain of all earthly things. Hence I give special statements of the size of excavation and prisms of ore ground in sight for each of the ore banks, in the chapter of this Report devoted to their local description.

The surface ore wash is of various depths from 1 to 30 feet. The breadth of surface covered is sometimes but a few yards; sometimes several hundred yards. Intervals occur where all traces of surface ore vanish fro n the belt.

The thickness of the underlying clays varies from a few feet to a hundred and more. Sometimes these clays are loaded with scattered pieces of ore, fine or coarse; at others they do not show a trace of ore. Sometimes the mass of clay is interstratified with layers of rock ore yielding richly.

The rock-ores and pipe-ores, bedded or in packets, under the clays are also excessively irregular, and nothing but actual mining can teach us the quantities concealed.

But any one who reads carefully the following descriptions of the ore banks taken up in succession, must arrive at the conclusion, that the Railway line connecting the ore deposits of Nittany Valley with Western Pennsylvania over Tyrone, and with Eastern Pennsylvania over Lewisburg, will have within the limits of my map, at its command for freight to distant iron works, many millions of tons of prepared ore of the choicest character.

One of the most noticeable features in the iron history of this district (and of others similar) has been denials of the existence of any ore just where the deposits were proved by subsequent diggings to be most copious, and predictions of the speedy exhaustion of ore banks which steadily grew in magnitude and richness as the excavations spread. The history of Pennsylvania Furnace Bank affords a notable instance, and not an isolated one.

There are not less than 100,000 linear yards of ore belt on my map. If the ore were continuous, and only 50 yards wide by 10 deep, we should have 50,000,000 cubic yards of ore ground. If only one-tenth of this were ore, we have 5,000,000 cubic yards of ore. It only needs to look at the number, breadth and depth of the diggings, and their distribution on the map, and to remember that none are noted there but the principal cuts; that large spaces of ore belt have for various reasons never been explored; that in some the ore is seen going down to unknown depths; and that in all the banks water has stopped work—to appreciate the inadequacy of the above calculation.

Special Descriptions.

I postpone further economical considerations to introduce here the data upon which what I have written above is founded. The situation and character of the principal mines, are given succinctly, but sufficiently in detail to permit others to form their own opinions.

THE PENNINGTON RANGE.

Cross section A B, fig. 2, shows the ore-bearing limestones at the Pennington Banks dipping *northwest*, and the hard limestones in the quarries on Logan's Creek dipping also *northwest* 23° to 27°, increasing (as we descend the creek) to 90°, and in some places overturned; then, rising at 53°, 54° (S. E. dip), to shoot over the Bald Eagle Mountain.

Cross section A B shows the same ore-bearing limestones at a point on the road to Huntingdon Furnace, a mile and a quarter southeast of the

FIG. 8.

Banks, and on the opposite side of the Ridge, dipping gently *southeast*, and making a strong outcrop of ore ground.

These are our elements of structure. Taken in connection with those of the Little Juniata River section, fig. 1, the geology is evident. There is a low anticlinal arch in the Pennington Ridge, and a sharply plicated little synclinal trough in the Valley of Logan's Creek.

The Pennington ore rocks descend into and beneath Logan's Creek Valley, at first slowly, then steeply, at last vertically, and before reaching the surface again on the other side of the little synclinal, are cut off by the great fault, and are sent down by it to a depth of many thousand feet beneath Bald Eagle Mountain.

On section line C D, fig. 3, no such structure appears; consequently the little Logan's Creek synclinal does not range away northeastward along the foot, but cuts across more northward into the flank of Bald Eagle Mountain.*

As for the Pennington Ridge anticlinal, it loses itself in the hill north of Warrior Mark Village, and in the great fault further on. Obscure dips† of 75° to 80° (N. W.) are seen in calc. sandstone at 500 yards northwest of the village, and 80° (N. W.) in blue limestone, at 450 yards further up Warrior Run; but the universal slant in the country, from here onwards, is southeast; all the outcrops beyond or northeastward of Warrior Mark Village belong to the *southeast* side of Pennington Ridge.‡

The Pennington Bank ore range is therefore a short one, whereas the next ore-range to the south of it runs continuously through Warrior Mark Village and Love Town for ten miles within the limits of our Map.

The Pennington ore rocks are also of an older age than those of many other banks in the Valley, as the sections show. They belong rather to the lower than to the middle division of the Great Limestone Formation. The Pennsylvania, Hostler, and other banks on the Spruce Creek side belong to the middle division. Any constant difference of quality observable between the ores is of course to be ascribed principally to this fact, viz.: that the ore bearing rocks being deposited in two successive ages, and therefore under different conditions, their present dissolubility and receptivity (as regards soluble salts of phosphorus, sulphur, &c.), have bestowed on them peculiarities of individual character.

I consider it possible that the Pennington Range corresponds in age with the Bloomfield ore range, in Morrison's Cove, thirty miles to the south.

The Pennington Range proper consists of a line of outcrops commencing about two miles from the Juniata River, and extending two miles to the railroad, a mile west of Warrior's Mark Village. The northwest face of Pennington Ridge is covered with wash-ore to a variable depth, below which lie sheets, belts, and masses of rock ore, between ribs of still undissolved siliceous limerock. The more argillaceous lime beds have left intercalated sheets of white clay.

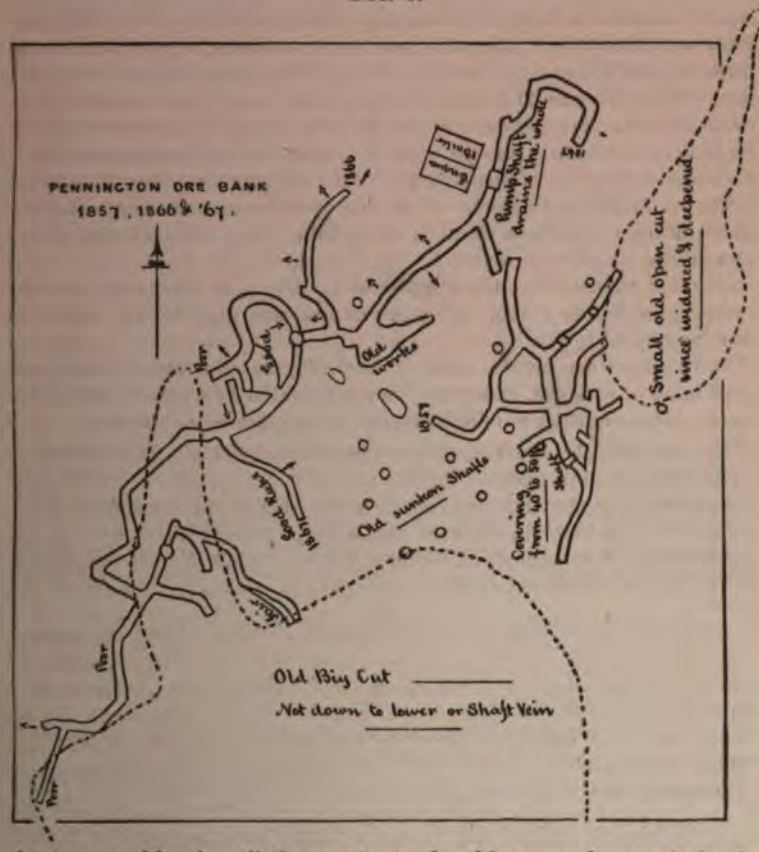
* The Map shows how it swings the mountain a little out of its otherwise straight course, and also how Logan's Creek takes its head just where its synclinal terminates in the mountain slope.

† The cross cleavage of the rocks near the fault makes the direction and strength of these dips doubtful. They look like 30° to 60° (S. E.)

‡ As will be abundantly evident to any one travelling along the road from Warrior Mark to Love Town.

No. 1. The Old or East Pennington Bank, supplied Bald Eagle Furnace with stock for many years. The ore was hauled about four miles over the mountain. It was chiefly got from the large open-cut shown in Local Map, fig. 8; but also from underground gangways following the ore down the dip (N. W.) beneath a clay covering; and from shafts sunk on that side, tunnels or rooms being driven from the bottoms of the shafts irregularly in every direction at the caprice of uneducated miners, who groped always in the dark, without correct geological ideas to guide them, following what they imagined to be the thickest beds and belts of the

FIG. 9.



best ore, and leaving all the rest to stand and be covered up again by the annual tumbling in of their shallow works. Most of these miners were Irish laborers paid by the ton. Water invariably stopped them, and limited the range of workings to a comparatively narrow belt down hill. The great deposits of ore unquestionably lying to the deep (N. W.) are unexplored. Neither maps nor notes of the old works exist.

Fig. 9 is a reduced copy of maps made by Mr. H. V. Böcking, mining manager of the Company, to show the position of shafts and direction of tunnels executed under his direction, in a more systematic way.

At the east end of the Old Bank, Mr. Böcking did much sinking on lower ground. One old shaft which had been abandoned at the depth of 30 feet on account of water, he sunk 30 feet deeper to the sandstone floor of the ore, which drained the mine. A cross-cut from this shaft 75 feet long struck the ore descending (N. W.) but where it was nearly level. Galleries were then driven and much ore won in an irregular way. But the heavy spring rains of 1857 filled the works to the top of the shaft. At this time the large deposit at McAtear's (West Pennington) Bank was discovered. In 1865 a new shaft was sunk, in a dry season, a little north of the caved-in works, reaching the bottom of the ore at 45 feet. The shaft was 60 feet deep, and a steam-pump kept it dry by two or three hours work per day. A good vein of ore had been abandoned (on account of water) in a smaller open cut, near the last mentioned shaft, with only 3 or 4 feet of dirt covering to the ore.

That the rich deposits of ore in the old open cut pass down northwestward, in irregular but continuous floors and layers between the clays, was proven by galleries driven by Mr. Böcking west from the pump-shaft, see fig. 9. He describes these galleries as driven in wavy ore, meeting several good bodies of ore. No pillar mining was done, as the sinkings were merely tentative.

In all this no account is made of anything but the better streaks of hard lump or rock ore, which alone a small charcoal furnace is willing to smelt. Great quantities of saleable ore and wash-ore are ignored.

My assistant, Mr. Franklin Platt, obtained the following imformation on the ground while making his map :—

Beginning at the Railroad, the first and smaller pit (now filled with water) 70 yards long, by 15 wide and 5 deep, yielded about 5000 cubic yards of wash-ore, without any solid lump ore. Shaft No. 1, sunk near it, (N. W.) is said to have passed through

1. Top wash-ore.....15 feet.
2. Rich lump-ore..... 5 "
3. Clay with little or no ore.....25 "
4. Good lump-ore.....15 "

the bottom not reported. Shaft No. 2, (W.) had lean wash-ore on top ; clay to 40 feet ; good lump-ore thence to bottom at 50 feet.

The main open cut is 230 yards long, with an average width of 35 yards, as shown in fig. 8 ; depth from 5 to 8 yards. Wash-ore, sometimes lean, forms the wall of the pit, from the surface to an apparent depth of 15 feet. A shaft midway of the eastern edge, "struck a layer of ferro-manganese ore, 5 feet thick, at a depth of 15 feet."

Two-thirds of the distance from the southern to the northern end of the pit, a massive crop of half decomposed calciferous sandrock charged with more or less of ore, juts from the wall, dipping gently northwest.

Some of this rock is genuine iron ore; the rest ferriferous or merely ferruginous sandrock. The excavated ore lay over, under and around this rock, having been freed from other similarly dipping, but more ferriferous and more dissoluble strata.* It is a place where the genesis of our brown hematites may be studied to advantage.

Ore was found in some of the shafts to the south-west of the main open cut.

The whole N. E. and S. W. extent of this uninterrupted expanse of wash ore, from the railway track to the shafts last mentioned, is about 500 yards, and its width, say, 100 yards. A considerable percentage may be too lean to wash.† Estimating the depth of soft and hard ore at 10 yards, we have 500,000 cubic yards. Rejecting one half for leanness, we are safe in supposing 250,000 cubic yards of ore in sight.

FIG. 10.

No. 2. The West Pennington Banks. An interval of half a mile separates this open cut from the East Pennington Banks last described.‡ The railroad, curving across a slight hollow in the side of the ridge, see local map, fig. 3, approaches within two hundred yards of the north

* The strike of this rock is *across* the open cut, here very narrow. The ore of the northern end of the cut is therefore above these rocks, and that of the southern portion of the cut belongs below these rocks.

† The "black ore,' which is very rich, is in some places abundant; in other places it becomes very thin.

‡ Mr. Böcking, speaking of this interval, says that after passing a low place at McAtear's, the main body of good ore was discovered in 1857, at the surface, on ground into which old pits had been sunk, the miners having previously condemned the whole locality. The very rich deposit then discovered lay higher up the slope of the ridge, and had thus been entirely missed.

Mr. Platt remarks: "What the original shape of the ore on the face of this ridge was, it is now hard to say; but the two Pennington ore deposits are at present separate and distinct, not necessarily connected in any way. I presume that the original limits embraced them both, and much of the ore lying between them which is now gone."

This agrees with what is seen at the Pennsylvania Ore Banks, to be described hereafter, and it is a strong argument in favor of the wholly outcrop character of these brown hematite deposits. On the other hand, the ore has never been properly followed to the deep, and the distance in that direction to which the dissolution of the ferriferous limestones and the precipitation of peroxide of iron has extended is unknown.

wall of the excavation, see fig. 11, which is 180 yards long, by 40 wide on an average, and shows nothing but wash ore in its banks. Its very irregular depth may be called 10 yards; water standing in the floor.

This cut was worked to a depth of 40 feet during seven years, and yielded richly. The first maps are lost. Mr. Böcking's underground works on the north wall, commenced in 1865, are represented by his Local Map, fig. 12, and thus described by him :—

An old whin shaft was pumped out, and pillars robbed. The galleries then caved in, and work stopped. Ore can still be reached from other shafts, two of which are timbered. One body of ore lies between the old cut and the underground works. It is not very rich, but is "good natured," and mixes well with more refractory ores. Another body of good rich ore remains standing to the deep of the works, and has a heavy covering. Another body of very good ore, fifteen feet thick, occupies a trough below the level of the pump-shaft, estimated at say 500 tons. Shaft 5 has ore around it. Shaft 4 is in a fair vein of rock ore. The deposit at shaft 3 is variable, and part of it stands. Old cuts and pits show that the deposit runs on southwestward.

That the ore extends northwards is shown by the late railway cutting 200 yards north of the open cut (see fig. 10), where ten feet of wash ore is seen overlying white and red clays.

Seventy yards southwest of the main open cut is another, 110 yards long, 15 wide, and 8 deep (13,200 cubic yards), nothing now showing but wash-ore in the side walls. It was originally much deeper, slides having partially filled it.

Three hundred yards west of the main open cut is the Old Phillips Bank, 100 $\times$ 30 $\times$ 6 yards (18,000 cubic yards), full of water. It was once deep, and drained by a tunnel, the mouth of which is shown on the Map (fig. 10), 140 yards from its west end.

Calling the length of ground occupied by these three open cuts, with their imperfect underground workings, 400 yards, and its breadth 100 yards, and assigning an average depth of ten yards for wash and lump-ore, we get an original mass of 400,000 cubic yards, one-half of which may be considered rich and accessible enough to work to advantage.

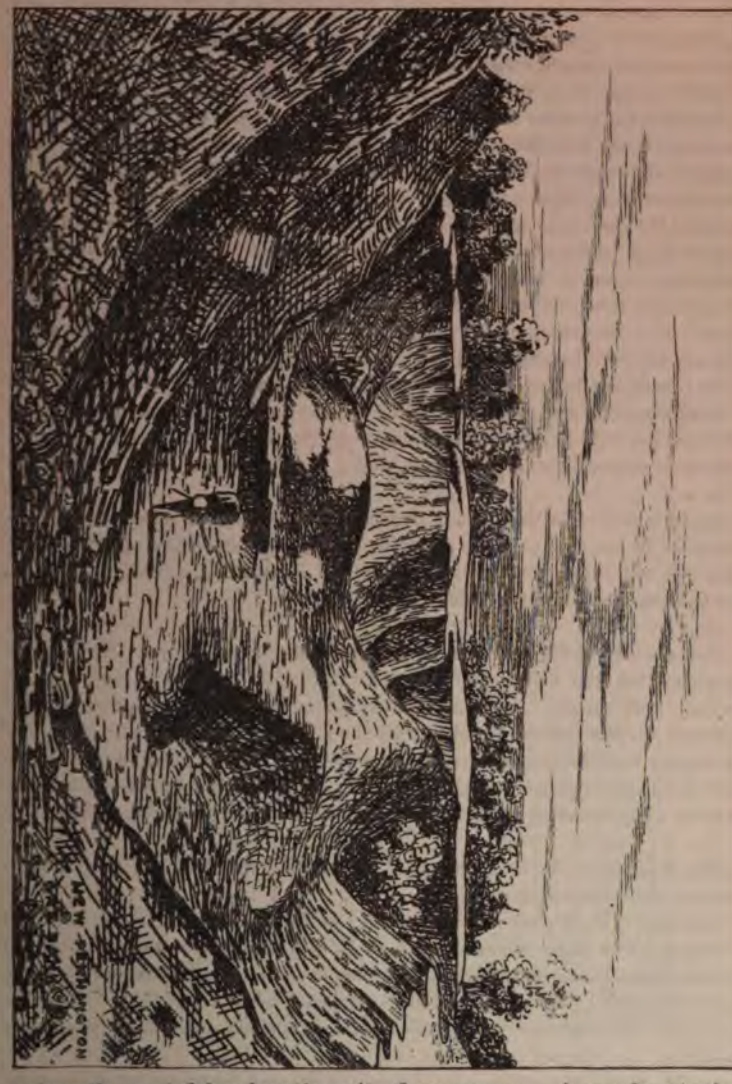
But it must be considered that this Pennington Range of deposits shows a much stronger tendency to develop lean layers and sandy masses than the Dry hollow, Red, or Gatesburg Ranges, hereafter to be described. Estimates of workable quantities are, therefore, hazardous. We are here geologically at the bottom of the limestones, and close on the top of the "calciferous sand-rock" formation, which accounts for the tendency to sand-rock and sandy ore exhibited in these banks.

Of the old Phillips bank Mr. Böcking says that it holds purplish easy smelting ore, mixed with clay, and without discernible regular veins. Quantities of wash-ore can be got here; but *dry* screening is impracticable.

This gives the key to the problem of the future. The near presence of

the railway makes systematic mining along this range a very different affair from the "ground hogging" of the surface hitherto pursued, un-

Fig. 11.



systematic, wasteful and costly as it of course was. A regular stoping of the deposit on a large scale and the washing of all the ore ground must yield a profitable revenue.

Mr. John W. Harden, an experienced Superintendent of mines, considers the extensive dry tailings, which cover the slope to the north of the cuts, capable of being profitably washed, while being got out of the way of future open cuts.

Traditional accounts of such old ore mines as these are to be credited with due caution and large allowances. But they have their value. It is of great importance, then, that shafts of over a hundred feet have been repeatedly sunk along this range; for they are proofs that experience has justified them; proofs that bodies of ore had been found lying very deep beneath the surface. The open cuts exhibited by the maps (figs. 8 and 10) were once very deep and were stopped by water, *as has been the case with all the ore banks of these valleys.* The miners were always driven from fine beds of rich rock-ore by the influx of water which they had no adequate machinery to keep under. We can easily believe it therefore, when we are told that in the Old Pennington Bank a floor of massive rock-ore from 8 to 16 feet deep underlies 50 feet of a covering, consisting of wash ore and scattered lump ore intercalated between white variegated sandy clays; and that in the West or New Pennington banks the deposit consists of a surface soil with a little ore 5 to 10 feet thick; then wash ore interstratified with layers and masses of white, brown and red tight clays and loose sands from 50 to 80 feet, and a floor of red rock ore underlying all.

My own belief is that when pumping machinery of adequate power comes to be applied to these deposits, and an approved system of mining adopted, many hundred thousand tons of ore will be raised and sent to the eastern furnaces at a living profit.

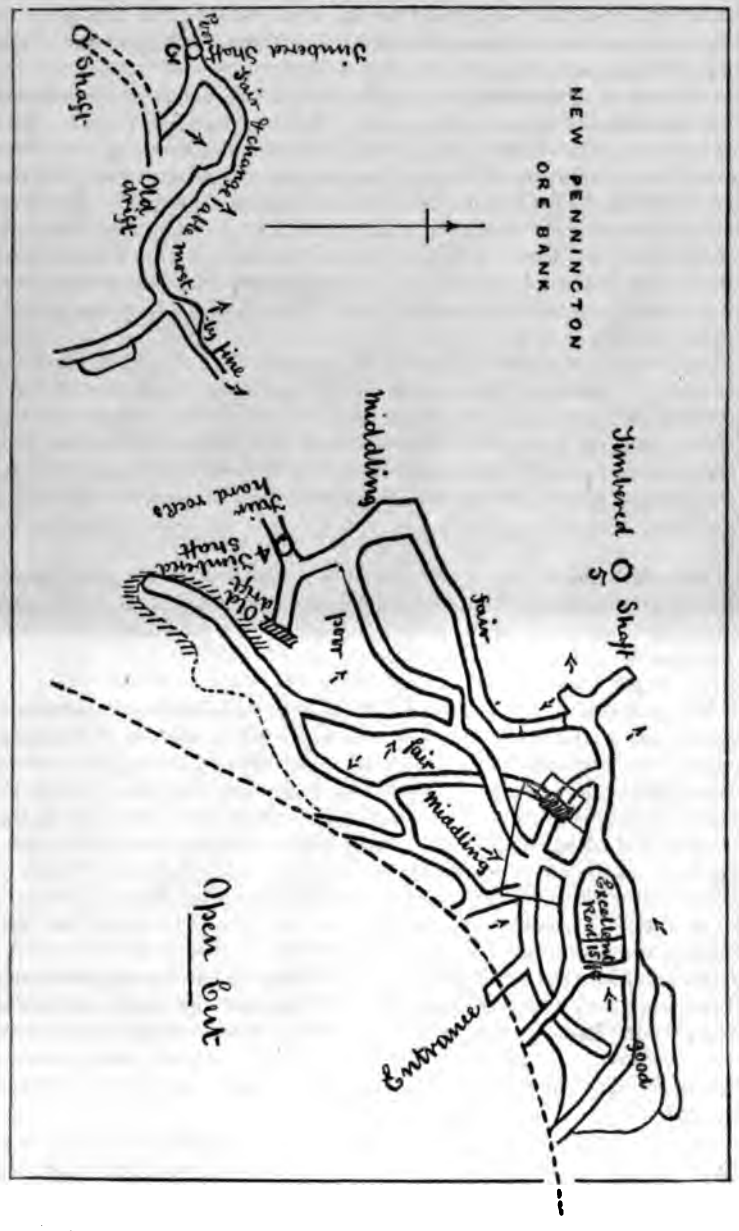
The southwestward extent of the deposits is unknown. But on the southwest of the ravine and hill spur beyond it a pipe-ore and a good deal of "barren ore" mark the continuation of the *Pennington outcrop* through D. Bronstetter's fields, and then across Gyer's farm. It is cut by a gap; and then is again visible crossing Weight's farm, and (on the west land line) reaching to the hill-top. Hence to the Juniata it is hard to trace; but becomes visible again west of the river in Sinking Valley.

No. 3. Beck Bank (marked "nameless" by mistake in the Key List on the large map).

The eastward extent of the Pennington deposit has not been carefully explored; but at the entrance of a R. R. cut, half a mile east of the Old Pennington Bank, Huntingdon furnace mined ore 10 years ago. This Bank shows $40 \times 20 \times 5 = 4000$ cubic yards of excavation, with water in the floor, and wash ore walls, rather lean in quality and quantity, as now visible.

No. 4. New Town Bank, also called **Beck's** (and so designated on the large map), lies $1\frac{3}{8}$ mile east of Old Pennington Bank, and was worked for Bald Eagle furnace, and abandoned for want of pumps to

FIG. 12.


NEW PENNINGTON
ORE BANK
Timbered Shaft
Shaft
Old drift
fair & change
table most
by fine
Middling
Timbered Shaft
Shaft
fair
poor
fair
Middling
Excellent Rod 15 ft
good
Entrance
Open Cut

keep down water, "good ore being left standing in the floor." In the woods behind Beck's and Aul's fields, north of it, small shafts were once sunk on fine sized ore. In Beck's Bank wash ore is seen in the walls, showing rather lean. At present there is not much evidence of the presence of a considerable deposit, and no encouragement is felt for looking for it.

The road to Warrior's Mark Village descends to Warrior's Run, past New Town Bank, which seems to be the remains of a surface deposit once covering the flat top of the Pennington Ridge Anticlinal. It is the only mine on this southeast dipping outcrop that has ever been opened west of Warrior's Run. But, that the ore belt extends in that direction, towards the Juniata, is proved by the heavy outcrop of ore ground, shown on the large map and on Cross Section A B, fig. 2, 1¼ miles due south of the Old (east) Pennington Bank.

The vein of ore pursued by those who worked the New Town Bank is described as small and irregular in thickness, and not traced successfully downhill and westward; but much coarse ore covers the ground in Jer. Berk's fields, on which the Furnace had no right to enter; slight shaftings showed small veins of ore. Further west also, in Adelberger's fields, some ore was raised; and outcroppings occur on P. Cooken's farm.

Warrior's Mark and Lovetown Range.

From Warrior's Run, north-eastward we have almost a continuous series of shafts and open cuts for a good many miles; viz:

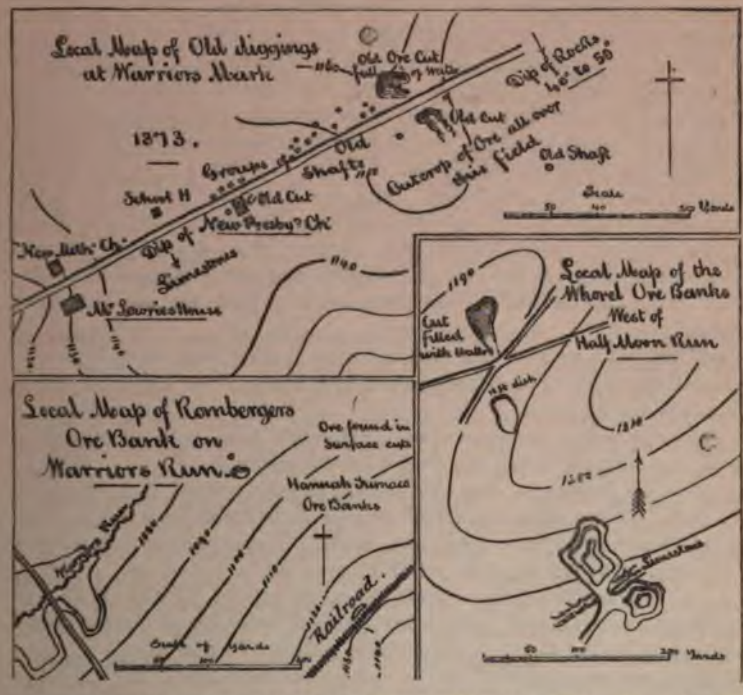
Old Town Bank (V) is ½ mile east of Warrior Run; Romberger's Bank (VI) 1½ miles; Hannah Bank (VII) 1¾ miles; Waite's Bank, 2¼ miles; Lloyd Braunstetter's Bank (IX) 2⅔ miles (with pipe ore outcrops to the south of it); Disputed Bank, 4¾ miles, (X); Hannah Furnace Bank, 5 miles; Hannah Furnace and Beck Banks half a mile north of the last two, and less than a mile west of Lovetown; the pipe ore outcrops half a mile south of Lovetown; croppings near the sawmill, 2 miles east of Lovetown; Hannah Furnace Bank and Bryan Bank, 2⅔ miles east of Lovetown, and the Curtin Bank 5 miles east of Lovetown, and 11 miles from Warrior's Run.

The ores of these Banks, when rich, are black or dark colored, much of it of a pitch-like lustre, and often inclining to cold-short in quality. Dr. Genth's analyses in my appendix will give their chemical constitution. When lean, they are of a lighter color, brown, or liver colored; clay predominating over sand in the deposit, as compared with the Pennington ores proper. Some of them may occupy a slightly higher geological position, being still further removed from the upper layers of the Calciferous Sandrock, and lying, therefore, still more in the body of the Trenton Group* of Limestones.

* See sections A B and C D. The Trenton Limestone proper, of the New York Geologists is considered to be the top member of the Trenton group. Our ores are far below it, and in the lower members of the group, viz. the Chazy, Bird's Eye and Black River Limestones.

No. 5. Old Town * Banks, are shown on Local Map, (fig. 13,); two old open cuts, one on each side of the main road, and groups of shafts, principally north of the road. There is a decided ore-show on the surface for 470 yards. Opposite the new church, an old shaft reached a maximum depth of 110 feet, touching "a vein of ore." (Böcking.) Contradictory accounts are now given of this work. Some say, that the quantity of ore was enormous, timbers 30 feet† long being used to support the chambers, the ore dipping steeply N. W.; and that massive

FIGS. 13, 14. FIG. 17.



ore stands in the sides and at the bottom of the deserted mine. Others say, that the ore mass, 25 feet thick, descended vertically with undiminished size when the shaft was abandoned. It is may be a deposit in one of the ancient caverns or cross fissures of the Limestone Formation.

Shafts sunk to depths of 30 and 50 feet sometimes went through clays without ore. Mr. Bocking sunk one 80 feet deep to find a mass of ore said to exist between three old shafts, but found nothing. The surface wash ore is sometimes only 2 or 3 feet deep; in other places 20 feet. No

* Called Town Bank, on the Local Map.

† The rocks of the neighborhood dip 25° to 35° S. E.

estimate of quantity is possible with such information. The visible area measures about 67,500 square yards.*

A little pipe ore has been found higher up the hill north of the road.

Regular and progressive stoping from the south-west, along the belt, may produce large results in the future. But the oreless clay of great thickness intervening between the surface wash and the deep hard ore will make mining expensive.

No. 6. Rumbarger's Bank, (Local Map, fig. 14,) is an open cut in the south bank of the east branch of Warrior's Run, the surface of the ground only rising 6 feet above the bed of the stream.

A cross-road separates the excavation into two; that on the southwest, 40 × 40 × 10 yards deep; that on the northeast, 30 × 30 × 10 yards deep; 25,000 cubic yards in all. These pits reached a depth of 40 feet, wholly in wash-ores and clays, without striking solid limestone. The rock ore left in the bottom when the work was drowned out, is *reported* to be less abundant than that found above it. But as the ore streaks "dipped fast to the southeast," and the limestone out-crops of the neighborhood dip from 22° to 34° in that same direction, (see Large Map,) good mining will probably yield well. Plenty of good ore has been won here, and nothing but the lack of pumping machinery stopped the winning. Thos. Funk worked the Banks at one time for the Milesburg Company.

The ore belt passes on eastward under Is. Buck's (now Smith's) lands, where Messrs. Green of Barree raised ore, but took no sufficient means for establishing a mine.

Thence it enters and underlies S. Hanna's farm, with its numerous ponds and sink holes, full of promise for the future.

A mine for Bellefonte Iron Works has just been opened (August, 1873,) at a point 300 yards northeast of Rumbarger's Banks, (see Local Map, fig 14,) where a very heavy outcrop exists. Every cubic yard is washed profitably. The cut is yet only 4 or 5 feet deep.

As a heavy surface show extends 150 yards beyond Hannah Bank, we have here an area of 450 × 50 = 2250 yards of wash ore of undetermined depth; besides the rock ore undoubtedly existing further down.

Mining and washing will here be cheap, and the railway runs along the hillside at a distance of 200 yards, and at an elevation of 35 feet, (fig. 14).

Further on, the surface show is slight, or wholly wanting,† until we reach the next excavation.

No. 8. Waite Banks, shown in Local Map, fig. 15, consist of two pits, 100 × 20 × 7, and 90 × 20 × 7 = 26,000 cubic yards, in size,

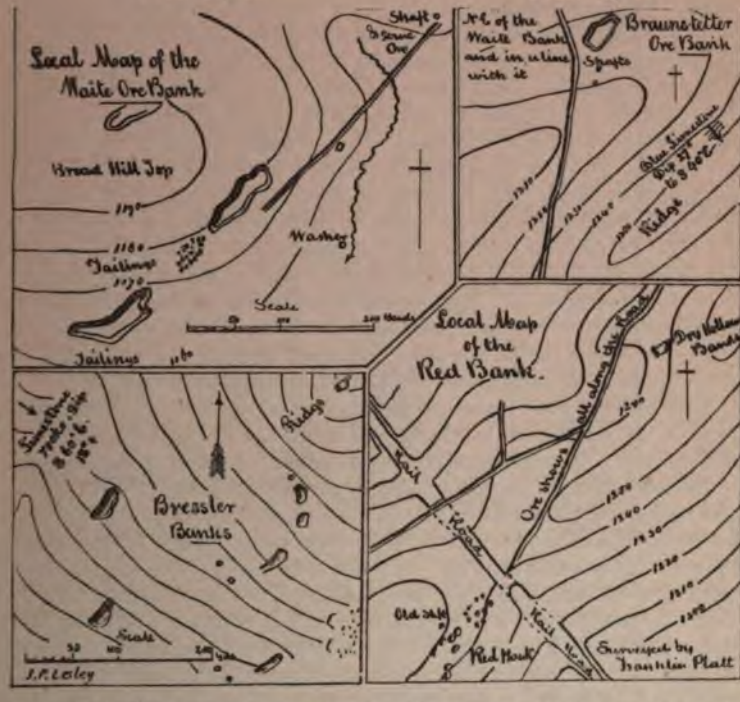
* Ore is found in the soil of Petershoff's farm on the south of the Town Banks. There is an old digging on the Hyskel (B. M. Thompson) farm; and further west outcroppings on Thom. Gano's, whose trial pit on a small vein near his orchard was stopped by water; lively outcroppings show in several fields up the slope of Dry Hollow ridge.

† A shallow pit ½ mile from Hannah Bank yielded some ore. The Waite Bank is 400 yards northeast of this shaft.

more than 20 feet depth of good-looking wash ore being seen in the sides, and much lump-ore having been won by still deeper shafts in the intervening ground. The entire ore prism must therefore exceed 150,000 cubic yards. The Railroad is a mile distant.

No. 9. Braunstetter's, or the McGlathery Bank, is situated about 1200 yards beyond (N. E. of) the Waite Banks, and the interval shows little on the surface; yielded only some lean ore to one or two trial

FIGS. 15, 16. FIGS. 18, 19.



pits. This Bank, (see Local Map, fig. 18,) is only $30 \times 20 \times 10 = 6000$ cubic yards large. It is said to have been worked to a depth of 40 or 50 feet, but is now fallen in and full of water, and no one seems to know much about it. Overlying Limestones crop out 150 yards southeast of it, dipping 27° S. 43° E.

Further on is the old Disputed Bank, on the high divide, between Warrior and Half Moon waters. Here are several small shallow open-cuts and shafts in surface ore; but no deep mining has ever been attempted. The ore seems to dip south, and is sandy. The crop traced westward, becomes good and plenty on Jos. Bronstetter's farm, who has never made

judicious trials of the deposit, and through the hollow leading to Patton's (now Waite's) and the Lloyd Bank, above mentioned.

No. 10. The Lovetown Banks, consist of numerous open-cuts and shafts from which large quantities of ore have been extracted and extensive preparations are in progress for regular mining of this important part of the ore field. The principal outcrop occupies a vale watered by a small branch of Half-moon. The old shafts of Abram Love were stopped by the influx of water. Pipe ore is visible near Love's barn. Half a mile west is an old "exhausted" Hannah Furnace Bank. On the north slope of the ridge west of Love's, ponds and sink-holes abound. Hannah Furnace had a Bank in David Berk's fields, and abandoned a good deposit of ore in its floor, merely on account of water. Surrounding shafts were also sunk, but no pumps were ever planted. A few hundred yards west of the open-cut, some of these shafts went through a pretty good "top vein" into a regular deposit 20 feet beneath the surface. Southwest of this other shafts were sunk for the Milesburg Company, in Abed. Stevens' fields, in good rich, sandy, black ore, close under the sod, the poorer clay ores lying down on the limestone foot of the hill. South of this, John Stine gathered much loose heavy ore from his fields, and hauled it to Bald Eagle Furnace, many years ago; but no sinkings were done. The outcrop is noticeable in Jos. Bronstetter's lane (leading to Wrye Bank) and in his fields on Cronister's line.

The Lovetown Banks are shown on Local Map, fig. 20, occupying two vales, descending eastward to the Half Moon Run, at the mill-dam.

A rib of solid blue limestone strata, dipping S. 30° E. > 56° to 57°, forms a low hill, up the south slope of which the wash-ore rides on to the flat summit. Natural ponds occupy, at points, the beds of the two vales.

The north line of the Love property commences near the Beck Banks, and runs down the northern vale to the corner of the mill-dam. The ore has been open-cut at Station 37, 165 yards west of where this line crosses the road. This once deeper old cut is now only ten feet deep, showing in its walls liver-colored, somewhat lean, wash-ore. West of it is a series of shafts for 450 yards, formerly sunk 60 or 80 feet (without timbering) until water was reached, and after a little side-drifting, abandoned. Hannah Funace ran for some time entirely on the ore got in this primitive fashion from these holes. In one of them (St. 39) pipe-ore was found. Nothing more is now known of them. They are evidently on a continuation of the Beck Bank deposit, the result of decomposition of ore-bearing strata *underlying* the rib of blue limestone at Station 56.

The rest of the ore on the property belongs to the series of rocks *above* the blue limestone, and to the southern vale.

The first shafts are sunk near Love's house. Shaft A struck ore at 35 feet; B, pipe-ore at 35 feet. Ore has recently been found southeast of A, on the foot of the opposite hill.

From Station 44 there extends east and southeast down across the

Fig. 20.

bottom of the vale, and west and southwest along the hill-slopes and hill-top, a universal surface deposit of wash-ore. In this area are numerous old shafts, pits, and open-cuts, and some new shafts sunk this summer and fall. The old works were always abandoned on striking water at various depths down to 80 feet, and are now filled up, and no records preserved. Much ore was certainly mined from them.

The new shafts show that from 8 to 15 feet of wash-ore in clay underlies the surface at the depth of a few feet, and that under the yellow and white clays there lie separate deposits of ore-lumps, the geographical intervals being barren. There seems to be no regularity of the ore layers.

The old shaft at Station 48 is said to have passed through twelve feet of surface wash, then (ore-bearing?) clays to a depth of 80 feet, into lump-ore, which was mined for several feet, and left in the bottom when water stopped the works. The new shaft, only ten yards southwest of the old shaft, is down 80 feet, and found no ore in the clays. The ore got seems rich and rounded, as if water-worn.

It may be safe to give twelve feet of wash-ore to the whole area, under which are hard ores, yielding sometimes richly and sometimes nothing.

The surface ore extends 850 yards along the top of the hill. Most of the pits were shallow, but one at Station 59 is said to have been 115 feet deep through wash- and lump-ore, with ore left in the bottom.

The general appearance of the deposit is the same as at the Dry Hollow and Wrye Banks.* No regularly interstratified ore is noticeable. No estimate of quantity can be relied on. Taking only the area of heavy surface show, and calling it 850 × 300 yards, and the depth twelve feet, we have 1,020,000 cubic yards of seemingly good wash stuff, which, at 3 cubic yards to the ton, gives 340,000 tons.

To this must be added the very uncertain quantities here and there scattered through the under clays. As these have been sometimes locally considerable, it is possible that one or two or even three hundred thousand may thus be obtained. As the principal part of the lump-ore is evidently at the bottom of the clays, no knowledge of the quantity can be got until systematic mining reveals the truth.

Wash-ore ground here must be considered as the main reliance for the present. Washing here is easy; abundance of water is struck at 50 or 60 feet, and there is plenty of room for settling dams. The railroad line, adopted for a branch to the main railroad, rises one mile on a 92 feet gradient, and descends one mile on a 46 feet gradient.

The ore has a much more extensive range than that above described, for Mr. Fisher has opened three small pits on ore just beyond the northeastern property line; and the Beck Banks show that it passes southwestward into the adjoining properties in that direction also.

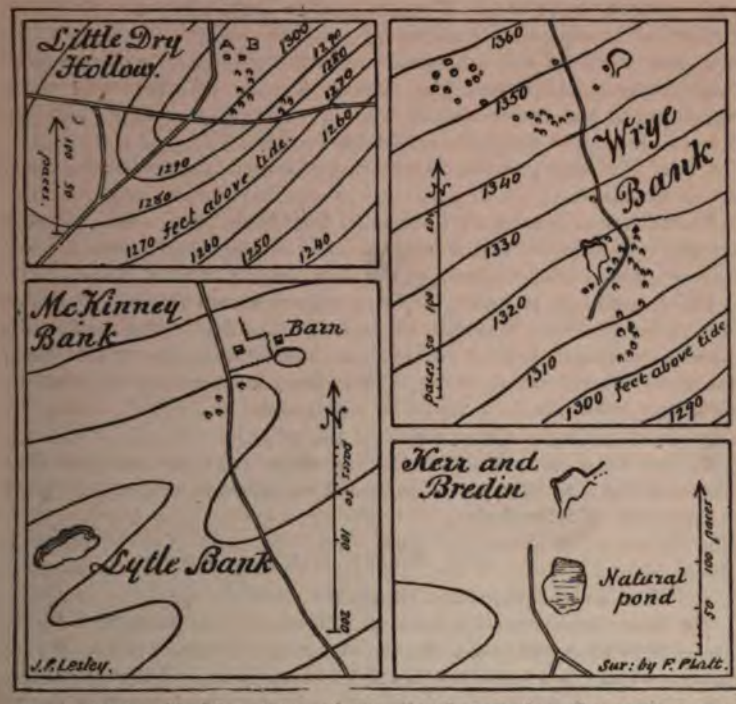
An analysis of Lovetown ore, from the large pit at Station 49, fig. 20, made at my instance by Mr. Persifor Frazer, Jr., Professor of Chemistry in the University of Pennsylvania, shows a percentage of phosphorus low

* Hereafter to be described.

enough to bring this ore within the limits of safe use in the manufacture of iron for the Bessemer process. The specific gravity of the specimens was 3 52. The calculated percentage of metallic iron was 45.36 ; alumina 16.53 ; silica 6.63 ; lime 0.58 ; sulphur 0.04 ; and phosphoric acid 0.05.

Between Lovetown and Stormstown (a distance of 3¼ miles) no ore is visible near Bald Eagle mountain, although considerable quantities of ore lie in the fields just northeast of Lovetown ; but on a line parallel with the mountain, and about a mile from its base, in a hollow leading from one branch to the other of Half Moon Run, a very fine outcrop

FIGS. 21, 22. FIGS. 23, 24.



range of tolerably big pieces of ore, closely covering the surface, runs past the sawmill. It leads directly to the two Bryan Banks, and is therefore important.

No. 11. Lytle's Bank ; No. 12. McKinney's Bank. These are the old Bryan Banks, 2½ miles N. E. of Lovetown, as shown at the eastern limit of the Large Map, and in Local Map, fig. 22.

The Lytle Bank was worked a long time ago for Hannah Furnace, and measures about $70 \times 20 \times 10 = 14{,}000$ cubic yards. Very little lump-ore is now visible, the walls showing about 25 feet thickness of wash-ore.

McKinney's Bank, worked for Pennsylvania Furnace, is much smaller, say $25 \times 20 \times 10 = 5{,}000$ cubic yards, and exhibits the same aspect.

Shafts sunk between the two excavations on both sides of the road, leading south from Stormstown to Gatesburg and Pennsylvania Furnace, always struck good ore, dipping to the southeast; as do the limestone outcrops of the neighborhood. We have here a prism of ore deposit at least $350 \times 100 \times 10 = 350{,}000$ cubic yards in size; probably, after all due allowances, quite that many tons of ore.

The **Curtin Bank**, a long, narrow open-cut on a prolongation of this outcrop, beyond the limits of the map, $2\frac{1}{4}$ miles N. E. of the McKinney, and the **Lamborne** Bank, $1\frac{3}{4}$ miles further in the same direction, have yielded cold short ores, similar in appearance to the Pennington. These and other works of less importance show the persistent straightness of the outcrop of the ore-carrying strata, parallel with the Bald Eagle Mountain, at the foot of which flows the east or main branch of Half Moon Run, with a limestone ridge* between the Valley of the Run and the ore. The Valley of the Run marks, of course, the line of the Great Bellefonte Fault.

At McKinney Bank we are three miles from the railway, where it strikes and begins to descend Half Moon Run. The Lovetown Banks require a railway two miles long, descending the west branch of Half Moon, with a grade of 40 feet to the mile, or else a railway across the ridge $1\frac{1}{4}$ miles long, with gradients 90 feet to the mile, as described. The line of the road was originally located to Lovetown, and thence down Half Moon; but it was considered more desirable to carry it across the Dry Hollow, among the ore-banks to be hereafter mentioned.

Before returning to these banks and the neighborhood of the railway, I will describe a group of banks lying south of the Lytle and McKinney Banks, at the east edge of the map, and on outcrops somewhat higher in the Lower Silurian Series.

Dry Hollow Range.

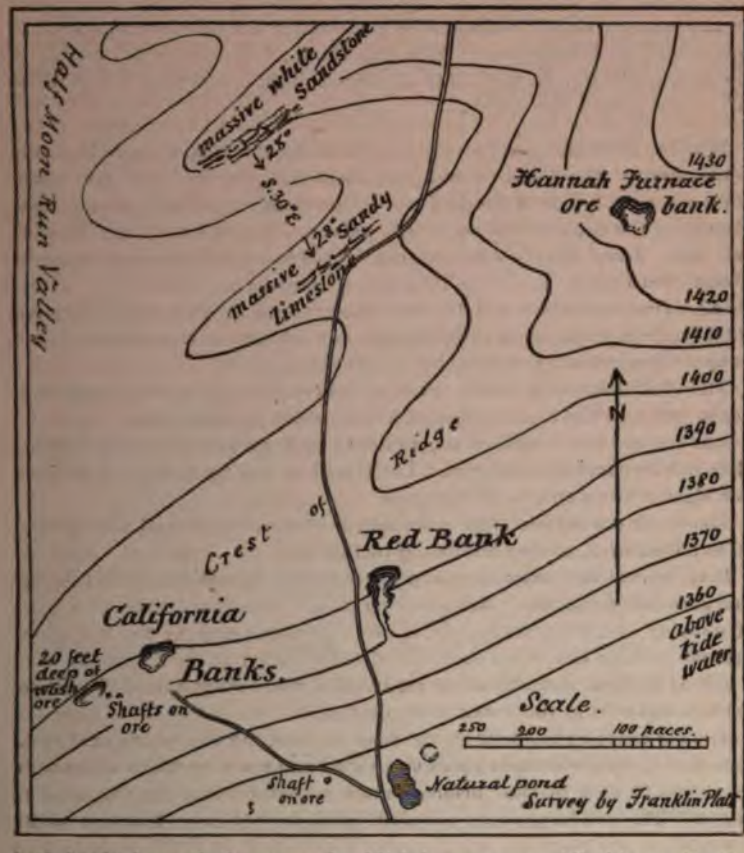
No. 13. Hannah Furnace Bank No. 2. Two hundred yards east of the Gatesburg road is a hole $40 \times 20 \times 10 = 8{,}000$ cubic yards in size, excavated on the broad, flat top of a ridge, as shown in Local Map, fig. 25. It was long ago abandoned. The ore seems good and abundant, 15 to 20 feet of wash-ore showing in the side walls, and coming close to the surface. All the down-slid stuff may be washed. Massive sandy limestones, 180 yards N. W. of it, dip S. 30° E. $>$ 28; 150 yards further N. W., massive white sandrocks dip the same.

No. 14, Bull Banks, half a mile east of the last, and in line with it, consist of two excavations on the south brow of the ridge; see A and B, local map, fig. 27. Much sandy ore was formerly taken out before these banks were abandoned, 20 years ago. $A = 60 \times 50 \times 10 = 30{,}000$, and

* This ridge, by an oversight, is not represented on the Map, no surveying having been done north of the McKinney Banks.

B=80×40×10=32,000 cubic yards. A shows wash ore in the side, which is 30 feet high above the water in the bottom. B shows about 30 feet of reddish wash ore, with very little lump ore, from the water to the surface of the hill. A neighbor who had worked in the pits, reports that several feet of deep brown richer ore was found lying everywhere in

Fig. 25.



both banks beneath the mass of reddish leaner ore. All this awaits the time of improved mining with pumps and washers.

Fig. 27 shows other old workings in the same deposit from 600 to 800 yards to the south-west of A and B. From two of these there have been taken about 15,000 cubic yards of wash-ore, which still exhibits itself 20 feet deep in the walls; the one furthest to the north-west in fig. 27, has been deep, say 40 feet, but now, like all the larger cuts, has standing water and mud in its bottom. Numerous shafts, all yielding ore, give

us data for calculating an ore prism in sight of, say 150×200×10?=300,000 cubic yards.

No. 15, Pond Bank, No. 1, worked for Pennsylvania Furnace, lies in the hollow at the foot of the ridge, ⅜ mile south of the Bull Bank, see local map, fig. 20. Its honeycombed, rather light, easy smelting ore, (mixing well with the more sandy ores of the Bull Bank Hill,) dips also south-east, and therefore belongs to a limestone out-crop still higher in the series, which is sufficient to account for its different quality. A great deal has been removed from this Bank; but much still remains to be won, and water to wash it is abundant. This is included in the prism of ore calculated last above.

No. 16, Red Bank, (Floyd's Old Bank) at the road side, half a mile south-west of the Pond Bank, (see Local Map, fig. 25,) is a cut in the same out-crop. The amount of ore is therefore very great; for the continuity of the deposits has been fully proven. The red rock-ore (35 or 40 per cent.) descends in a solid stratum from 8 to 10 feet thick, at a dip of about 25° to the S. E. Over this lies a stratum of white clay, 3 feet thick. Over this black ore in solid masses and great lumps scattered thickly or thinly through several yards of wash ore, to the surface. Some of these lumps are 2 feet long by 1¼ feet thick.

This Old Gatesburg Bank, as it is sometimes called, was worked 40 years ago, and has been re-opened now to show its character.

The red ore was too siliceous, and hard to work in the small cold blast charcoal furnaces of the region; but it will be eagerly sought by modern hot blast coke or anthracite furnaces.

The black ore masses were selected for charcoal cold blast use, having 50 to 55 per cent. of iron and being fusible ore.

It is impossible to say how deep these strata descend on their 25° dip in a peroxide condition. But allowing only 100 feet, we have in a mile of outcrop 150,000 cubic yards of red rock ore; and as the wash ore ground holding the black lump ore descends with it, and spreads over a belt of surface more than 100 yards wide, there must a be half million cubic yards of it at the lowest computation.*

The old cuts at the elbow of the road west of the two ponds in fig. 27, have had about 8000 cubic yards excavated and are now filled with water to within 10 feet of the urface, showing that much wash ore without lumps. The two larger cuts 150 yards north-west of them, measure about

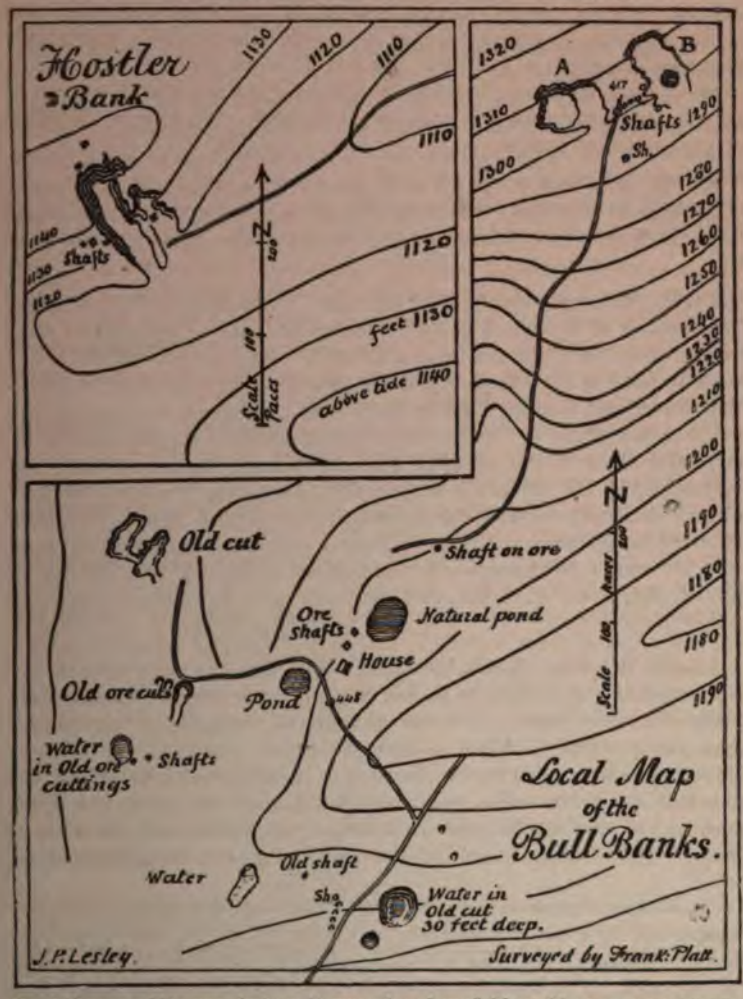
* I have described above only what I saw. Mr. Platt was informed that under 12 feet of clay holding black lump ore, lay 4 feet of white clay without ore, under which lay 14 feet of red rock ore in red clay, and ore was still underfoot. I give this report for what it is worth.

Mr. Böcking speaks of red rock ore only 6 feet thick, "and another fair layer in the clays above, all workable; red ore not very rich; silicious, but with visible sand; rich black ore in the top vein, [the word he always uses for a stratum of ore]; on the whole, proper for coke furnace use; mining requiring pumps; deep workings at hand; an important locality."

15,000 cubic yards, with 21 to 25 feet of wash and lump ore in the walls; abandoned 20 years ago.

No. 17. California Bank, 200 yards west of the Red Bank, and on the same slope and outcrop (see Local Map, fig. 25, (received its name from

FIG. 26. FIG. 27.



the richness of its ore, before it was abandoned 20 or 25 years ago, on account of its distance from Pennsylvania furnace, the abundance of water and lack of pumping apparatus, the refractory quality of its mineral in the cold blast charcoal stack, and especially the abundance of

good ore at the Furnace itself. Pits of standing water show 20 feet of wash ore in their walls.

This completes my sketch of this "dry hollow" outcrop east of Half Moon Run. It is a dry hollow because the whole limestone underground is cavernous, and water springs up abundantly in every excavation, but does not flow over the surface. This is a prime factor in the problem of he genesis of these ores, and must be taken into consideration in all speculations respecting the depths to which the brown hematite ores descend in a minable form.

The outcrop belt of surface wash ore and regular rock ores in which the Hannah Furnace, Bull, Pond, Red and California Banks are excavated, passes on north-eastward into the untried wilderness of the Barrens, where we find upon it the Floyd Bank, an open cut on highland; ore very sandy for charcoal furnace use, but good and abundant for hot blast coke or anthracite; and good charcoal ore could be selected from it still.

No. 18. Reider's Bank, half mile east of Gatesburg, is a small surface opening of $30 \times 20 \times 5 = 3000$ cubic yards extent. On trial at Centre and Hannah Furnaces it was refused. The surface of the broad low hill north of the village is a sheet of wash ore. The roads north to Stormstown and west to Warrior Mark expose ore ground at the surface, on the slopes of the dry hollow in which the village stands, and to the north and south of the village. The old opening on the roadside 250 yards south of the village, is entirely filled up. Considerable quantities of very rich lump ore were taken out here many years ago, mostly from underground galleries. Much ore ground occupies the surface for more than 100 yards north-eastward. Limestone crops out 300 yards west of it dipping S. 30° E. $>$ 20°, and 300 yards north of it dipping S. 30°E $>$18°.*

No. 19, Whorrel Bank, (see Local Map, fig. 17,) is a continuation south-west across Half Moon Run of the Gatesburg outcrop, which is here nearly 500 yards broad. The open cut on the north side of the Gatesburg road is about $40 \times 13 \times 5 = 2600$ cubic yards; that on the south side $30 \times 20 \times 3 = 1800$ cubic yards. Both have standing water in the bottom, and wash ore in the walls, while very heavy outcrops appear along the road, as well as along the cross-road leading up the ridge north to Lovetown, beyond which an old shaft has struck the underlying sand rocks.

The double excavation in fig. 10, $110 \times 40 \times 7 = 30{,}800$ cubic yards large, is separated by a stratum of limestone dipping S. 30°E., $>$26°, (one exposure looking like $>$50°,) the ore underlying, overlying and surrounding one end of it. The wash ore in the sidewalls does not look rich. It is reported that these holes were dry 40 feet deep and yielded good ore.

* The horizon of this and the Whorrel bank is still higher in the series than the last, as Section C D (fig. 3) will make evident.

The length of the surface show *i. e.*, S. W.—N. E. is only 50 yards, to be terminated by the erosion of Half Moon Creek Valley. The railroad is only 400 yards distant.

Fig. 28.

No. 20. Pond Bank, No. 2. is a small excavation $35 \times 10 \times 5 = 1750$ cubic yards, at the head of the hollow, or rather on the divide where the south branch of the long Dry Hollow proper begins to descend towards

Warrior's Run ; and along side of one of the summit cuts of the railroad. Good wash and lump ore show in the walls. No sandy ore is seen. The R. R. cut shows 10 feet of wash ore for a length of 100 yards. Altogether we have here say, 40,000 cubic yards of ore in sight.

No. 21. Wrye Bank. The local map, fig. 23, shows this extensive group of shafts commencing 450 yards northwest of the railway track, at an elevation of 40 feet above it, and continuing along the road up the slope to an elevation of 100 feet above the R. R., a distance of 400 yards. Over most of this surface the show amounts to little, proving how little we can rely on the surface indications as negative testimony. For, these works were extensively driven from 1852 to 1857, and yielded some very rich ore, while the surface showed only poor sandy ore.

There is one open cut, $25 \times 20 \times 10 = 5,000$ cubic yards large, showing wash ore in the walls from top to bottom, none of it rich, decidedly sandy, holding ironstained calc. sandstone masses, as at the east Pennington Banks. Very good open ore, bluish, and heavily charged with manganese occupied the west end of this open cut (Bocking). An old miner reports, that in the shafts they went through 26 feet of pretty worthless loose stuff and then worked 18 feet of good lump ore, without getting through ; that the shafts up the hill were dry ; those lower down quickly filled with water, and were therefore abandoned, one after the other, before they could get out more than 10 or 12 feet of lump ore. What the charcoal furnace miners called worthless is now valuable for hot blast, especially anthracite furnaces, and the whole of this great deposit will be washed and sold. The breadth of the belt of shafted ground is about 100 yards, but must be considered as indefinitely greater along the strike.

I am informed that in these old diggings the body of ore sank to 50 feet beneath the surface and thinned away, but came in thick again lower down, and approached the surface. Two good pillars are known to be left standing in the old works, under a top covering of sand, one at the lower end, the other at the upper end of the works. In the last, solid rich rock ore lies 45 feet beneath the surface. All the shafts are now caved in. The ore layers were traced for several hundred yards eastward by trial shafts.

The appearance of this ore differs from that of the Pond Bank No. 2 so much that we should suspect them to belong to a different geological horizon. This suspicion is almost confirmed by the general southeast dip of the outcropping rocks here and there exposed at the surface. This important structural question is clearly expressed by my Section C D (fig. 3), which passes through these banks. It is quite certain that the rocks which on dissolution delivered these ores, are the mother rocks also of the Kerr and Bredin, Hostler and Pennsylvania Furnace ores to be described hereafter. The great breadth of the Dry Hollow Outcrop belt corresponds with that of the localities just named, and I think it pretty evident that we have here two horizons of Lower Silurian ore-bearing limestones close together.

The old **Sandy Bank** is a group of small shallow pits, in very sandy

surface ore, but rich and good when washed, on the hill slope a few hundred yards northeast of the Wrye Bank, showing the continuation of the outcrop in the direction of Half Moon Run.

In the other direction, the outcrop has been exploited at the old **Pond Bank** of Bald Eagle Furnace, 500 yards southwest of Wrye Bank, and nearly in the bottom of the vale, which deepens rapidly.* It lies close to the foot of Hickory ridge; ore light but good, not sandy, and easy to smelt. A pond, dry in dry seasons, covers some of the old diggings. Much surface ore covers the neighborhood, and it will hereafter be an important mining ground, with heavy clay cover to the ore, requiring hard pumping.

Top ore of large size abounds around a sink-hole in Isaac Gano's fields, on the north slope of Hickory Ridge, a mile S. W. of the pond. The pieces seemed rolled from an outcrop of good ore seen half-way up the hill, in the Huntingdon Furnace woods.

At **Simpson's Bank** ($\frac{3}{4}$ mile further west) the wash-ore is good and easy to smelt. Whereas at **Andrew's Bank**, adjoining, (the Warrior's Mark and Pennsylvania Furnace Road separating them,) sandy ore only has been taken from the open cuts, but no shafting done.

Jos. Krider's fields are covered with very rich scattered pieces of ore, some lumps weighing 400 pounds. Attempts to find a bed at a little gap near by, have failed thus far. The shafts were tried in thick woods; others were too low on the hill slope, and encountered only wash ore. There is undoubtedly a heavy rock-ore deposit somewhere. Similar shows are again seen half a mile further on (west) opposite the old wash-machine, and Huntingdon Furnace has picked off the surface much of this loose block-ore. A small layer was found in two or three shafts, but never followed up to see what would come of it.

No. 22. Dixon's Banks are only a few small holes, fallen shut, with a slight sandy ore surface show, 100 yards west of the road, where it crosses the head of the middle branch of the Dry Hollow. Here "a small irregular vein yielded good ore a little west of it, on a detached knoll, a thicker vein of poorer, flinty ore was found, at the edge of a pond, and was thought not to pay for pumping, to get for charcoal furnace use.†

* This and the following named Banks are not exhibited on the Large Map, because not accurately located. Their descriptions I got from Mr. Böcking's notes.

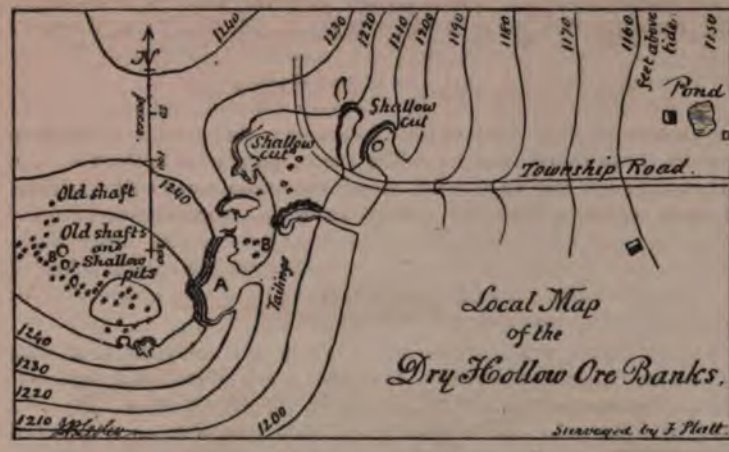
† Mr. Böcking thinks he remembers that this vein had a decided northern pitch, and distinguishes it thus from all the other veins of this range. This must be either a mistake or a mere local accident. Mr. Platt's field notes also mark a doubtful N. 30° W. > 34° dip of the limestones in the through-cut 240 yards northwest of Railroad section stake 81-80. But 100 yards N. E. of the same stake, soft rotten limestone strata dip S. 30° E. > 20°. Other Railroad exposures show that the S. E. dip dominates the structure. Thus at Railroad station 4145, is a thorough-cut in blue limestone, dipping S. 30° E. > 34° with regular cleavage planes N. 60° W. > 70°; at 4151, a good exposure of limestone gives S. 30° E. > 26°. In Railroad cut at 4164, sandy and blue limestones the layers seem to dip S. 60° E. > 31°; in the cut 180 yards S.W. of Railroad 4180 hard, sandy limestones dip S. 45° to 50° E. > 26°.

The old **Kelsey Bank** yielded much good ore, years ago, in funnel shaped pockets, not continuous.

No. 23. Little Dry Hollow Banks (see Local Map, fig. 14) are near the crest of the low hill dividing the middle from the north branch of the Dry Hollow. No. 1, is a small hole on a small outcrop reported to have yielded six to eight feet of sandy lump-ore, soon running out No. 2 consists of a group of small pits and trial shafts on a slight outcrop. Some ore was got from shafts A, B, and C. The appearances here are not favorable for future mining prospects.*

No. 24. The Dry Hollow Banks are the central figure in the broad expanse of outcrop which seems to fill the hollow and its three head branches, and to cover the dividing slopes, in many places if not continuously, north of the Railway. They are shown in map, fig. 29.

FIG. 29.



In the south-east corner of this map, the railroad curve ought to have been designated, the distance of the track from the principal excavation A, being less than 400 yards.

The cut on the south side of the township road is pictured by Mr. Harden, in fig. 28; that on the north of the road in fig. 30; and the road itself in fig. 31; the wash-ore in the R. R. cutting at the curve, south of the banks, is shown in fig. 32.

The Dry Hollow Bank, ½ mile north of the R. R., 2½ miles E. of

* Mr. Böcking reported some years ago that these works merely won small veins and top ore, while the body of ore is undoubtedly left under the little ponds, &c., at the foot of the hill. Good ore used to be raised from the Little Dry Hollow Bank, but efforts to "recover the vein" some few years ago failed, although the ore here rides to the top of the hill, where it is pipe-ore (as it also is pipe-ore on the northern side of the hill).

Warrior's Mark Village, is an extensive system of open cut excavations, from which great quantities of excellent ore have been got in past times. The term "system" is however inapplicable to the process of mining here employed, for it resembles rather the burrowing of animals. No

Fig. 30.

Part of Dry Hollow Bank. South side of Road.

one can estimate how much of the precious ore has been left untouched, for there are neither maps, nor records, nor traditions of the work.

The old miners merely say that the ore runs out against a bank of clay. But such reports are good for nothing; and even if literally true teach

Fig. 31.

Road to Warriors Mark through Dry Hollow Bank.

nothing, for they are sure to relate to single points, and fail of application at others. Fifteen years or so ago, some of the old pillars of ore were taken out by sinking shafts and driving short galleries at a few points. The ore is mostly wash-ore, that is fine ore disseminated through

clay. The dip is southward (towards the great central synclinal) and deep workings and powerful pumps are needed, in future, south of the old shallow surface workings.

From Dry Hollow Summit Cut for the Railroad to the first shafts, a distance of about 400 yards, there is a decided outcrop. The shafts extend over 200 yards to the edge of the big open cut A, fig. 29. They seem to have gone down* through wash and lump ore 60 feet to water, which in all cases stopped the works. The lumps alone were carried to the furnace. The wash-ore was not valued then ; now it is merchantable. The sinking was done at random and ore was always got.

Mr. Platt's estimates on the ground are as follows :

110×40×10	=	44,000	76,000 cubic yards of excavation done.
50×15× 8	=	6,000	
50×15× 6	=	4,550	
60×25×10	=	15,000	
50×10× 5	=	2,500	
100×10× 4	=	4,000	

The main bank A, shows wash-ore of very variable richness from top to bottom, 50 feet. The shafts at B are reported 60 to 70 feet deep, through wash and lump ore. From shaft C, on the roadside, 60 feet deep, 1600 tons of excellent lump ore alone was selected for use.

About 300 yards north-east of the Banks, the railroad line has exposed a mass of lump and wash ore of excellent quality.

The **Old Red Bank** of Bald Eagle Furnace is on a continuation of the Dry Hollow deposit south-west, but higher up the hillside. It is shown in local map, fig. 19. Mining was confined to the surface ore which was sandy and without 'regular veins ;' but no one knows how the deposit of ore is to the deep.

The surface show between the Dry Hollow Banks and the Red Bank is not so heavy as where the old excavations were made ; but the deposit underneath is really continuous and unbroken, as is shown by the cuttings through the ridge made by the railway between the two localities. See fig. 19.

Here wash ore has been exposed for 100 to 125 yards along the track ; sometimes 10 feet thick resting on clay ; sometimes 20 to 25 feet of wash ore holding larger lumps. The varying thickness of the red clay and ore layers in this cut is an instructive example of what the miners found in their shafts. Some of the lumps weigh 300 to 400 lbs. Very few pieces of silex appear ; and on the whole, this deposit looks freer from silica than any in the valley. Little or no soil covering exists.

The Red Bank pits and shafts are very numerous, and all shallow. The ore when smelted alone, at Bald Eagle Furnace, made first class iron.

From the south-west end of the Red Bank to the north-east end of the Dry Hollow Bank is about 1000 yards. The breadth is 200 (say 150)

*25 years ago, more or less.

yards. The worked depth (to water) varies from 20 feet at Red Bank to 100 feet at Dry Hollow Bank. Taking an average of 10 yards, we have 1000 $\times 150 \times 10 = 1{,}500{,}000$ cubic yards of wash and lump ore. Discard one-half of the leaner interval between, and allow one ton to the yard in consideration of the size and quantity of lump ore, and we have 750,000 tons.

Fig. 32.

In our ignorance of the condition of things where the water stopped the old fashioned rude mining, it is impossible to say how near this estimate approximates accuracy.

No. 25, Bean Bank lies a mile to the S. West of the Dry Hollow Bank, where many tons of surface lump ore were scratched out and

sent to Huntingdon Furnace; as was done in other places along this part of the range on the South Slope of Dry Hollow Ridge. No attention was paid to the great body of wash ore forming the deposit, and no effort to mine to the deep. A vast body of ore ground awaits future exploration and excavation, within a mile of the railroad. Quartz occurs in this ore bank.

No. 26, Bressler Bank, (see fig. 16) is a collection of small holes, on the north-west side of the ridge, in a ravine descending to the east branch of Warrior's Run, and distant from the railway, half a mile. About 2500 cubic yards of excavation seems to have been made in past years. The pits are fallen in, showing sandy wash ore in their sides. Eight feet of lump ore is reported as mined in this locality. No geological indications of the structure appear.

This completes all I have to say here of the Dry Hollow outcrop. For, although ore has been found further south-west along the south side of the ridge towards Warrior's Run, no mining has been done; and the Old Seat Bank, (No. 37,) is so out of line with the Banks above described, that it may be left for notice in connection with the ores west of Warrior's Run. But I shall describe, further on, the continuation of this range where it crosses Warrior's Mark Run and at the Huntingdon Furnace and Dorsey Banks.

I pass over, therefore, to the Cale Hollow (Kerr & Bredin, Hostler and Pipe-ore) Banks further south-east.

The Cale Hollow Range.

Cale Hollow is divided from Dry Hollow by Hickory Ridge, as shown in the Large Map; and its ores lie in a deeper and narrower synclinal than the ores in the gentle and wide synclinal of the Dry Hollow as shown by section CD. They are, however, ores once carried by the same limestone strata, and ought therefore to be of the same general character. It is therefore remarkable that so little pipe ore has been found in Dry Hollow, while an abundance of pipe ore characterises the Cale Hollow Banks.

No. 27. Kerr & Bredin Bank, (see local map, fig. 24, and wood cuts 33, 34, 35,) is a small excavation of about 5000 cubic yards, showing in its walls lump and wash ore, 25 feet deep. Much of the wash ore seems leaner than in other Banks. A shaft has been sunk for exploration in the bottom of the old cut, and the report of it is favorable to future mining on a systematic scale. (See wood cut, fig. 35.)

The ore from this bank won for itself a high reputation at the furnace. It was called "gun metal ore," and was said to bear a striking resemblance to the Bloomfield ore of Morrison's Cove, south of Holidaysburg in

Blair Co., from which was made by preference the ordnance of the U. S. Army during the civil war

Fig. 33.

Part of the Kerr and Bredin Bank, sketched by J. W. Harder.

Dr. Genth's analysis of the Kerr & Bredin ore, given below, when compared with Dr. Otto Wuth's analysis of Bloomfield ore, made June 9, 1871, compare as follows :

	Kerr & Bredin.		Bloomfield.
Ferric Oxide	70.67	Perox. Iron	78.63
Manganese Oxide	0.36	Manganese	0.29
Cobaltic Oxide	trace		—
Alumina	3.91		2.50
Magnesia	0.26		0.38
Lime	trace		0.34
Phosphoric Acid	0.19		0.134
Silicic Acid	5.48		7.02
Quartz	6.80		—
Water	12.33		10.71

The extra quartz determined by Dr. Genth, diminishes the percentage of iron oxide in his specimens, and reduces the percentage of iron from 55.04 (Wuth) to 49.47 (Genth). Otherwise the ores are strikingly alike.

The **Kerr & Bredin** Bank lies at the foot of the south slope of Hickory Ridge, one mile W. N. W., of the Hostler Bank. In a dry autumn Mr. Bocking was directed to sink south of the old cut, and to mount a pump. He reported a 12 inch "vein of ore" at 40 feet, and water at 44 feet. A tunnel-way was commenced in the direction of the old cut, which caved in, and the works were stopped.

The continuation of these ores along the foot of Hickory Ridge, on the north side of Cale Hollow, is proven by a range of "lively outcroppings." In some places the surface is sufficiently rich wash-ore. One or two pits (Bronstetter's) were worked, for Huntingdon Furnace, 1½ miles west of the Kerr & Bredin Bank, in "an irregular vein."

Northeastward the ores continue to show themselves to Half-moon Run, where "pipe-ore" is marked upon the large map. See Little Bank, below.

From a small cut at Eyer's, on the east side of Half-Moon Run, pipe-ore was raised many years ago. The limestone rocks at Eyer's house, 100 yards south of the spot, dip to the S. 30°, E. > 21°.

Another old pipe-ore locality shows now fair ore on the surface, near two small trial pits.

No. 28. Hostler Bank (see local map, fig. 26, and wood-cut fig. 36). This excavation occupies the northern slope of the Spruce Creek anticlinal ridge, as a large open cut, from which the ore was in old times hauled to Pennsylvania Furnace, two miles due east of it.

The recorded history of this important mine reveals the following features. Wherever the diggings were made they went down through "pipe" wash-ore which was occasionally mixed with lump-ore, to depths of 60 and 65 feet, in all the shafts.

One of these shafts passed through this wash-ore 65 feet, and then passed through a stratum of solid limerock, varying in thickness from 10 inches to 2 feet. Below this limestone lay lump "pipe" ore, into which

the shaft was sunk 6 feet further and then the flow of water stopped its further descent.

From the bottom of the shaft a five inch auger hole was then drilled through a continuous bed of pipe ore to an additional depth of 39 feet.

FIG. 34.

The percentage of iron in the pipe ore is uniform; or varied only by the chemist's including in his analysis adherent or enclosed clay.

It is a constant feature of the Pipe ore banks of the southern range that they do not furnish the "lean ores," so-called, which are met with

in the Banks opened along the more northerly and geologically lower outcrops of the "Barrens" in this valley. It has been the uniform experience at the Pennsylvania, Hostler, and other Pipe ore banks that shafts and borings have always passed through lump-ore, after having been sunk or drilled below water level. But as pumping apparatus on a sufficient scale has never been applied to such deep shafts and borings, they have in no case passed through the deposit of lump ore, the thickness of which is therefore still a matter of conjecture.

I give the history of these operations as an evidence of the insufficient extent to which the development of this iron-ore district has been carried; to show that only its surface has been scratched, but its deposits not mined. Regular, systematic, efficient operations are yet to be begun. They await the completion of the railroad and that demand for large quantities of ore from distant furnaces which is already become so urgent. The underground drainage all through the Valley is immense, and the largest bodies of ore, and especially of pipe-ore, can only be won with heavy pumping and systematic stoping.

The Hostler open-cut Bank must be sunk in air to the lower ores, and through them to the bottom floor of all; then with powerful pumps to keep the water down, the clay stripping above can be washed, and the heavy face of ore below can be stoped and the top stuff thrown back into the abandoned ground as the ore-face advances. As Mr. Bocking justly remarks, "35 feet of ore will well pay for stripping 65 to 75 feet" of clays above it. He adds, and I agree with him heartily: "The time for shallow digging and ground-hogging is pretty well past in these barrens, and the exploration of the richer banks may require in future preparations that will take some capital, and may need in some cases two or more years before yielding a return."

The Hostler Bank excavations measure about $120 \times 50 \times 10 = 60{,}000$ cubic yards. The ore lies like that to be described in Pennsylvania Furnace Banks, as a mass of clay and wash-ore separated by ribs of undecomposed limestone. The walls are about 30 feet high, but the high northwest dip of the measures prevents this figure from being used as a datum of calculation. It only shows in a general way the depth below the sod to which the weathering action had gone, *as exposed by the miners.* The late sunk shafts passed alternate soft beds of ore and hard ribs of limestone, all on a steep dip; 38° to the N. 35° W. In a shaft at the northwest end of the open cut one shaft went down through 75 feet of wash-ore ground before striking the solid limestone rocks and water.

It is impossible from such data to estimate the future yield at this locality, but the amount of ore to be won must be very great. Nor is it confined to the neighborhood of the old works. The ore-belt runs on southwestward for at least five miles.

At the distance of 1,900 feet there are somewhat less than twenty old shafts in one group, quite forgotten until recently discovered by Mr. George Lyon. They were mostly shallow pits in the surface of the pipe-ore bearing clays; but some of them look as if they had been sunk to a considerable depth; and their number proves that the search for ore was remunerative even at that day.

This part of Cale Hollow is a wide, flat, slightly undulating, dry vale, every part of which shows a top-dressing of fine ore. It is a virgin district. Mr. Lyon sunk one trial-shaft in it, and struck an "ore-

FIG. 35.

A Section at Kerr & Bredin Ore Bank.

vein." There was a similar accidental discovery of another group of five or six pits from which some top-ore had been scraped. I have no doubt that a continuous belt of mining ground runs the entire length of Cale Hollow.

The **Red Bank**, 1¾ miles from the Hostler, on the same slope of the Spruce Creek Ridge, is old and disused, the ore in the top clays was stripped, but no attempt at deep mining was made. Another old bank in line with it, but across a little ravine issuing from the ridge, furnished some pipe-ore to Huntingdon Furnace. Still further west,* in a similarly

* 4½ miles from Hostler Bank.

situated bank, near Huntingdon Furnace, a vein of good, red-short ore was struck, and abandoned on account of water. On working one part of this pit the ore became too sulphureous to use. It will be again referred to after describing Bank No. 29.

The belt of Cale Hollow Ores may be traced northeastward with the same general character.

Little Bank, for instance, lies two-thirds of a mile northeast (near the Warrior Mark Pennsylvania Furnace Road), 1⅔ miles west of Pennsylvania Furnace. Here very rich top-washings cover a high flat area connected with Hickory Ridge. Seams of the ore penetrated the limestone rocks all the way down a 40 feet shaft, under which the main body of ore dips northward.

The **Eyer Bank** (already mentioned) is an old excavation one mile still further east, on the east side of Half-Moon Run.

Going on northeastward across a dividing ridge, the ore appears again along Tadpole Run, in Sleepy Hollow, and at the head of the Beaver-dams, for a distance of more than a mile. Years ago, some pipe-ore was raised, for Centre Furnace, east of B. Crane's, but the surface was merely scratched. At the Pennsylvania Furnace old surface-pits, sunk at the beaver-dams, the body of ore probably lies under the bed of the run and would require heavy pumping.

The "dry hollow" which carries the Valley of Tadpole Run on in a straight line northeastward, and is a geological prolongation of Cale Hollow shows plenty of out-croppings of ore, just as Cale Hollow does, and the ore is of the same kind—pipe-ore. In fact the ore belt continues to McAllister's and the School House cross-roads, eight miles northeast of the Hostler Bank, and far beyond the limits of my large map.

Between McAllister's and Pinegrove Mills, the country spreads out into a plateau two or three miles wide, through which runs the Brush Valley Anticlinal. Here, far beyond the east limit of my map, are the

Old Weaver Banks; two open-cuts and several shafts near them, abandoned years ago. No systematic mining was attempted in that early day, the work being done by the farmers. Tradition speaks of "ore veins" being reached, but probably too well watered for the natives to cope with them. "The ore lying around the holes is not a regular pipe-ore, but is mixed with liver-colored ore, and reported red-short." We have here, then, ores not belonging to the Hostler and Pennsylvania Pipe-Ore Bank system connected with the sandstones of the anticlinal, that is, ores belonging to the underlying limestone.

Spruce Creek Range.

No. 29, Pennsylvania Furnace Ore Bank. For about fifty-eight (58) years Pennsylvania Furnace has been supplied with its stock from the extensive excavations on the gently-sloping south side of the anti-

clinal ridge facing Tussey Mountain ; Spruce Creek, above the Furnace, flowing between the ridge and the mountain.

See local map, fig. 37, in lieu of further description ; and the landscape sketches of the excavations, to illustrate their extent and character : figures 39, 40, 41, 42, 43.

The geologist can here study the theory of the formation of the Lower Silurian Brown-Hematite ores of Pennsylvania to great advantage. I know no better place, and few so good.

The ores are evidently not washings from a distance ; neither from Tussey Mountain, nor from the present surface of the anticlinal ridge ; nor from any formerly existing surface in past geological ages, when the surface stood at a much higher elevation above sea level. They are evidently and visibly interstratified with the soft clay and solid limestone

Fig. 36.

THE HOSTLER ORE BANK

layers, and obey the strike and dip of the country ; the strike being along the valley, and the dip about 49° towards the southeast.

Thousands of minor irregularities prevail ; the streaks of ore and masses of clay, are wrinkled and bunched, and thin out and thicken again in various directions. But all this irregularity is owing to the chemical changes of the strata, and to the changes in bulk of the different layers during the protracted process of solution and dissolution, during which the looser calciferous and ferriferous sandstone layers have lost their lime constituent, packed their sand and clay more solidly, and perhydrated their iron. In this long process cleavage-planes have been widened into crevices ; caverns have been excavated ; pools or vats have been created ; precipitates of massive (rock and pipe) ore have been thrown down ; and a general creeping and wrinkling of the country been effected. But the original general arrangement or stratification has been preserved ; and those portions of the whole formation, which had but little lime, have

been left standing as sandstone strata; while others having but little sand remain as solid and massive limestone strata; those which had an excess of alumina are now in the condition of streaks, masses, or layers of white or mottled clays; and only such as were properly constituted clay-sand-lime-iron deposits originally have so completely dissolved as to permit the lime to flow off, and the iron to consolidate into ore.

Every stage of this interesting operation, and every phase which it presents in other parts of the Appalachian belt of the United States, from Canada to Alabama, may be seen and studied in these old and extensive ore banks of Pennsylvania Furnace.

At first sight of the bank the ore deposit looks as if it were a grand wash or swash of mingled clay and fine and coarse ore grains and balls, occupying hollows, caverns and crevices in the surface of the earth and between the solid limestone rock; and some of it undoubtedly has been thus carried down into the enlarged cleavage partings of the limestones; and into sink holes and caverns formed by water courses; where it now lies, or lay when excavated, banked up against walls or faces of the undecomposed lime rocks. But as a whole the ore streaks and "main vein" of ore must occupy nearly the same position originally occupied by the more ferruginous strata after they had got their dip and strike. See fig. 40.

The ore is taken out with the clay, and hauled up an incline, by means of a stationary steam engine at its head, and dumped into a large washing machine, with revolving screens; whence after the flints and sand stones have been picked out, it is carried on an ironed tramway, to the bridge house of the Furnace. See fig. 43.

The ore forms from 10 to 50 per cent. of the mass excavated, and the small amount of handling makes the ore cheap.

The floor of the excavation is about sixty (60) feet below the level of the wash machine.

Shafts sunk from 30 to 35 feet deeper, in the floor, to a permanent water level, have shown that other and even better ore deposits underlie the workings, covered by the slanting undecomposed lime rocks. This is an additional demonstration of the correctness of the theory above stated.

The upper ores will furnish stock for yet many years. After that, or in case more furnaces be erected, or distant markets call for the shipment of ore by railway, deep shafts or bore holes must be sunk to drain the underground, and the lower ores may then be lifted to an extent which can hardly be estimated now.

The prism of ore *in sight*, technically speaking, if calculated roughly from the areas exposed by the old and new open cuts, and by shafts sunk at various times and in various parts of the floor, gives several millions of wash-ore, lump-ore and pipe or rock ore. Thus taking the area exposed at say 550 $\times$ 450 yards, and the depth at only 15 yards, we have 3,612,500 cubic yards, which on washing would yield 602,000 tons of prepared ore.

FIG. 37.

Local Map
of the
Pennsylvania Furnace
Iron Ore Banks,
in 1874.
Aquaduct.
Pipe
Tramway.
Washer
Outcrop of Limestone
Quarry for flux.
Engine
Spruce
Scale of paces.
Surveyed by Mr J. Platt
Above tide 1120 ft
J. P. Lesley

Of this, about 100,000 tons have been passed through the furnace, yielding nearly 50,000 tons of neutral cold blast charcoal iron of the best quality, leaving 500,000 tons of ore to be excavated.

But this is only a portion of the deposit; for the ore ranges away beyond the high walls of the open cuts into the surrounding land an unknown distance. The large area stripped last year towards the northeast shows how extensive the deposit is in that direction.

Add to this the great depths to which the ore is known to descend, and it seems to me certain that a million of tons is as probable an estimate as a half a million. Large quantities of ore are left standing between the hard limestone ledges exhibited in figure 40 (taken from *a* in local map fig. 38), and in figure 34, which is an enlarged view of the sharp promontory seen in fig. 33, sketched to show its geological structure. The dip of these limestones is to the S. 35°, E. > 35° to 40°; and they are exactly on range with the limestone outcrop along the road, at the quarry, and

Fig. 38.

past the Furnace, as shown in fig. 37. Slight crumplings of the limestone vary the dip from 18° to 65°; but these are due either to movements in the yielding ore mass or to a deception caused by mistaking cleavage planes for bed plates. No such variations are apparent at a distance from the banks, the whole limestone formation descending uniformly beneath the foot of Tussey Mountain with a dip of something under 40°.

The pictures figs. 41 and 42 are views of the deep cut looking east from *a* in local map fig. 37. The view in fig. 43 is taken looking northward into the main ore bank, from near *a*; and it shows the new incline, the washing house, and the ridge above it, along the crest of which the aqueduct is carried on tressels, for 2000 feet. Fig. 38 shows the end of the aqueduct where it is mounted by the pipe leading up the hill-side from the double Worthington pump in the engine-house, fed by another pipe from the dam. Behind the hill seen in fig. 43, in a hollow on a level with the northeast end of the banks, is the settling-dam.

FIG. 39.

Pennsylvania Furnace, Old Banks. Sketched, November 1873, by J. P. Lesley.

The height of the walls of the various excavations may be seen by reference to the ten foot contour lines in fig. 37. These also show that the ground now so deeply excavated once formed a high divide between a vale descending southwest to Spruce Creek, and a corresponding but shallower vale descending northeast to the settling-dam hollow. It looks as if the ore once filled both these vales, but has been excavated by the natural drainage into Spruce Creek, from the one which descends in that direction, and, perhaps from the valley of Spruce Creek itself, down to and beyond the Furnace.

The entire walls of the cuts are of wash ore, and it is all torn down and taken to the washing machine. But the tops of pyramids of solid pipe ore are exposed in the floor, and some reached to, or nearly to the sod above. At one of the deepest places in the floor, 60 feet below the sod a shaft was sunk 40 feet further through solid pipe ore, and then limestone, and was stopped by water. Water does not stand in the present floors on account of the free circulation, at a still lower depth, through crevices and caverns communicating with Spruce Creek, which itself issues from a cave.

The books at the Furnace show as an average for some years, 6 tons of wash ore to 1 ton of ore; 2 tons 1 cwt. of ore to 1 ton of iron; and $2.25 per ton of ore delivered at the Furnace, represents the cost of mining, inclusive of all expenses.

I shall give in an appendix, the opinion of Mr. Harden on some practical points which I requested him to study, for which purpose he visited some of the Banks described above.

Outcroppings of ore occur east and west of the Pennsylvania Furnace Banks on the southern slope of the anticlinal ridge facing Spruce Creek and the Tussey Mountain; but no excavations have been made, because sufficient stock was always procurable at the Banks near the Furnace. It is not to be supposed, therefore, that equally large and important deposits may not be exposed by future systematic mining operations, when the completed railway shall make demands on this ore belt for supplying the furnaces of Eastern and Western Pennsylvania.

Some of these surface-shows of ore are near the top, others near the bottom of the hill slope. The ore surface is commonly high up on the slope, or on the flat rolling back of the anticlinal ridge.

John Ross has in his fields, north of Pinegrove Mills, (miles east of Pennsylvania Furnace,) an old funnel shaped hole, from which very rich pipe ore was taken, and more can be seen in its sides, but no surface-show; and I have no data on which to base an estimate of quantity. The ore was sent to Monroe Furnace; was rich; but very red-short: lumps of pyrites being visible in the bombshell ore lying about the hole; which is also coated with white sulphates.

Surface ore can be traced all the way from Ross' to Pennsylvania Furnace, but no search underground seems ever to have been made or called for.

In the other direction, down Spruce Creek, south-west of the Furnace, a few outcroppings on the surface appear, but lie neglected for the same reason. A few trial-pits seem to have been sunk near the school house,

Fig. 40.

and near Mr. Geo. Lyon's mansion, south of the turnpike. Large pieces of pipe ore lie in the east corner of Mr. Thos. Lyon's fields, at the foot of Tussey Mountain. Ore has also been noticed in Mr. Stewart Lyon's north fields.

All the above are on the south slope of the anticlinal of Brush Valley, facing Tussey Mountain. The anticlinal may be studied where the limestone rocks are seen dipping both ways (N. W. and S. E.) in the end of the hill at the Furnace, and in the railway rock-cuts as the line makes its semicircle down Half Moon Run and up Spruce Creek and Tadpole Run.

Three miles further down Spruce Run a pipe ore bank was commenced on the south slope of the Anticlinal, to supply works erected at the mouth of Spruce Creek, for a patent process to convert the ore directly into wrought iron; but the patent process failed and the mine was never worked. It sufficed to show that the ore belt or outcrop follows the ridge along the north side of Spruce Creek towards the Juniata, but coalesces with that of the Cale Hollow, or north dip, beyond Huntingdon Furnace, and sinks beneath the surface, for no trace of it is found in the Little Juniata River section, where the Canoe Valley anticlinal may be seen replacing this of Brush Valley.

Returning thus to Warrior's Mark Run, and the neighborhood of Huntingdon Furnace, I have little to add to finish this report, except concerning an ore belt, west of the Run, on the south slope of the ridge in line with the Dry Hollow Banks. But before speaking of it, I shall give the following section up Warrior's Mark Run :—

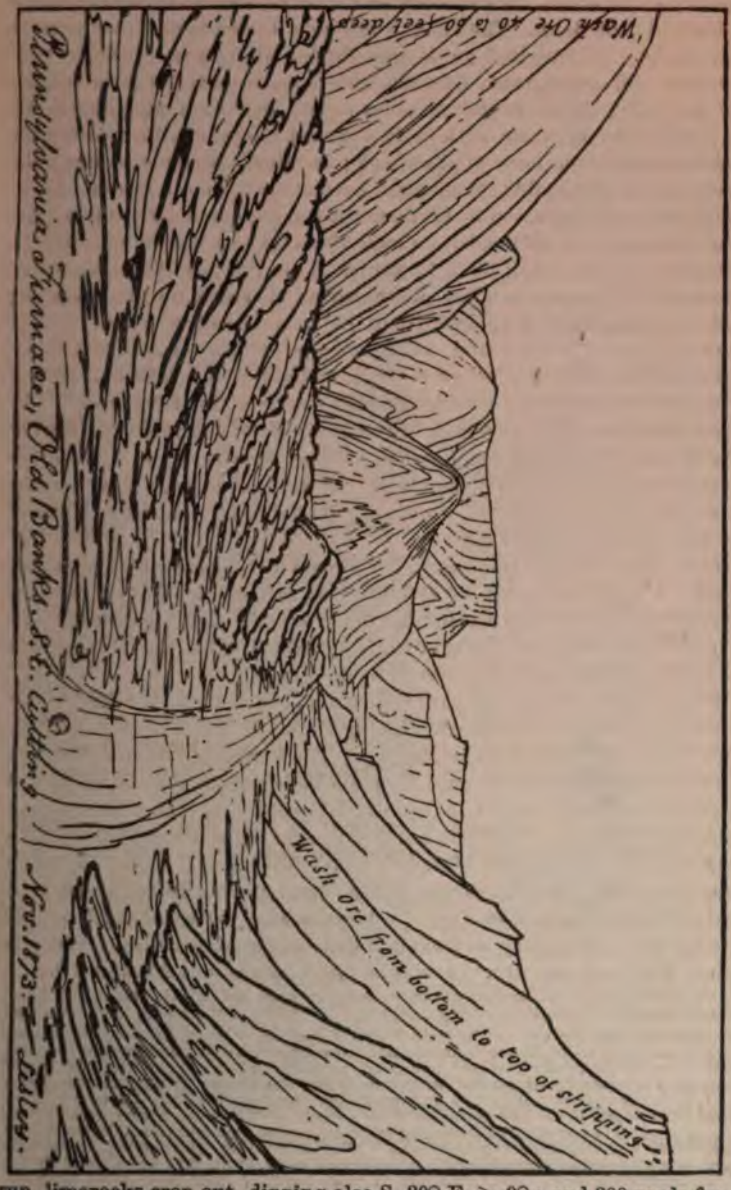
At the mouth of Cale Hollow, in the north dipping rocks of the Spruce Creek Ridge anticlinal, and 150 yards east of the mill-dam, or a mile east of Huntingdon Furnace, there is marked on the map an old pipe-ore bank, now fallen in. Lime rocks here dip N. 30° W. > 50°; but, by the road-side, 300 yards to the west-southwest only 38°; and in the hill-side, 650 yards to the west-northwest, 12° in the other direction S. 30° E. The Old Seat Bank, No. 30, is 1,100 yards distant (up Warrior's Run towards the N. N. W.) from this old bank. The Cale Hollow is thus seen to be synclinal, and, allowing for the different strength of dips observed there can be no reasonable doubt that the same ferriferous limerocks out-cropping here outcrop also at the Old Seat Bank; and I have so drawn the Section A.B.

The ore at this old bank is reported to have been extraordinarily charged with sulphur; but I could not learn exactly in what form.

No. 30. The Old Seat Bank, on the east bank of Warrior's Run, 2½ miles below where the railway crosses the run (at Warrior's Mark), is an old open cut with ore in its floor, abandoned many years ago for want of pumping machinery of adequate power. What little liver-colored ore is visible, looks lean, and much flint lies about. The area of the cut may be 4000 square yards. Water stands in it to within 10 or 12 feet of the top. It has been worked to a depth of 40 feet. About 30,000 cubic yards of ore-ground has been taken out. Although much liver colored ore like Pennington ore lies about, no pieces of sandstone are visible; but a good deal of flint is among the ore, as at Pennsylvania Furnace Bank. Not much surface-ore shows in the neighborhood.

In the gap of the Dry Hollow Ridge, six hundred yards higher up the

FIG. 41.



run, limerocks crop out, dipping also S. 30° E. > 9° ; and 300 yards fur-

ther, sandy limestones, S. 30° E. > 10°. 500 yards further up the run, pipe-ore is reported, ploughed up in the fields. This belongs to an ore-bearing strata about 700 feet lower in the formation than the ore horison at the Old Seat Bank. The dip is continuous and equable; there can be no mistake. 500 hundred yards still further up the run, at the forks of the road, still lower sandy limerocks are seen dipping the same way, S. 30° E. > 13°. Other exposures occur in this interval dipping also S. 30° E. > 13°. No dips are noticed in the next 1000 yards, to the toll-gate and cross-roads and forks of the Creek; but there is no reason no doubt that a southeast dip fills the interval, becoming ever more gentle.

Five hundred yards southwest from the toll-gate, and 50 yards off the road (towards the northwest) on land 70 feet above the water, is an old deserted pipe ore bank 50 × 10 yards. This lies just 1000 yards due northwest of the pipe ore last mentioned as ploughed up in the fields; and if a continuous southeast dip of 10° be *supposed*, we should find in it an evidence of a third and still lower pipe ore horison, 550 feet below the second and 1250 feet below the first, or Old Seat ore horison. But it would be very unsafe to consider this the simple state of the case. The place where ore was "ploughed up over a space of 600 yards" is worthy of a thorough investigation, but the surface show is slight. The other locality where lumps and pipes of solid ore were got 25 years ago from the open cut and underground works, is reported to be rich still. None of its wash ore was taken away.

This place is very important. It proves conclusively that pipe ores occupy a *geological* range of at least 1250 feet of the Lower Silurian Formation. And these exhibitions on Warrior's Run connect the rich Dry Hollow Group of Banks already described, with the Huntingdon Furnace and Dorsey Group next to be described.

The toll-gate is only 800 yards down the run from where the railway crosses it. And the southeast dipping Beck and Town Bank ores (Nos. 4 and 5) are only 400 yards further up. The Beck and Town ore horison therefore underlies the toll-gate ore rocks (unless there be some concealed disturbance in the interval), at a *geological* depth of at least 1200 feet, and probably 1500 feet. For there are 20° dips (to the southeast) in the railway cut, and 35° dips in Warrior's Mark Village. If I am anywhere near the truth, the Pennington Range ore horison (Becks, Town, &c.) underlies the Cale Hollow Pipe Ore horison at a *geological* depth of 2500 to 3000 feet; which may well explain their different qualities. And this result is in harmony with features of my cross-sections AB and CD.*

* The Pennington and Lovetown ores being on the same geological horison, and there being a breadth of limestone outcrop (dipping S. 30° E. > 50°), between Lovetown and the Bellefonte fault at the foot of Bald Eagle Mountain, at least 700 yards broad, we have about 5000 feet of Lower Silurian measures visibly exposed underneath the Cale Hollow (= Pennsylvania Furnace Bank) ore horison. Adding to this the 2500 feet of limestones between Pennsylvania Furnace bank and the foot of Tussey, and we have a total thickness of Lower Silurian Limestones from the bottom of No. 111 (the Hudson River Slate) down to the jaw of the Bellefonte Fault, of 7750 feet; a very great thickness; but quite in harmony with all that we know of the Trenton, Black River, Bird's Eye, Chazy and Calciferous in the Great Valley of Reading, Harrisburg, Chambersburg, Winchester and Knoxville. This, so far as I know, is the first approximately accurate measurement of these formations in mass south of their New York outcrops, which are very thin in comparison with these.

No. 31, Huntingdon Furnace Banks. These lie along the southerly slope of a prolongation of Dry Hollow Ridge, west of Warrior's

FIG. 42.

Run, and within a circle swept around Huntingdon Furnace with a radius of two miles, as shown on the land-map. The Dorsey Banks are outside

this circle, but are excavated in the same belt of outcrop. The outcrop is very broad because, as we have just seen along Warrior's Run, the southeast dip is very gentle, about 10°. This has allowed a very large dissolution of the ore-bearing rocks.

The **Wilson Bank** is two miles west of Warrior's Run; no ore has been found in this interval, the slopes being sandy. Here limestone begins to come in, overlying the sandstone, and ore-bearing clays take possession of the surface. This sandstone has been mistaken for the Calciferous Sandrock; but must be one of the numerous intercalations of sand in the great limestone series.

The **Keefer Banks** follow, in the next half mile, and, although exhausted as to the wash ore of the outcrop, can be mined to the deep if proper pumping apparatus be mounted to keep the underground water down.

Fig. 44 gives a local map of these excavations, which severally measure, as they come in order along the line of Mr. Platt's survey :—

a.	*	130 × 30 × 8	=	31,200	cubic yards.
b.	*	160 × 35 × 8	=	44,800	"
c.	†	40 × 25 × 10	=	10,000	"
d.	‡	120 × 40 × 8	=	38,400	"
e.	§	100 × 40 × 8	=	32,000	"
f.	§	30 × 30 × 5	=	4,500	"
Total excavation, say,				161,000	cubic yards.

No. 32, Dorsey Banks, see fig. 44.

These works lie just outside the two mile circle around Huntingdon Furnace Stack (see Land-line Map), and are used for Barre Forge, distant three miles due west on the Little Juniata River; the nearest distance to the river by the Township line in a southwest direction being two miles.

There is first an open cut on the south side of the road, see fig. 44, measuring 65 × 25 × 6 = 9,750 cubic yards of excavation, with wash ore in the walls. Then, a shallow open cut, ten or twelve feet deep, 75 × 30 × 4 = 9,000 cubic yards, the floor being everywhere wash ore.

The Main Bank, in the southwest corner of fig. 44, is divided by a slide of the southeast wall into two open cuts, 200 × 70 × 15 = 210,000 cubic yards, with wash ore walls and floor (now generally 30 feet deep), but excavations have been made much deeper.

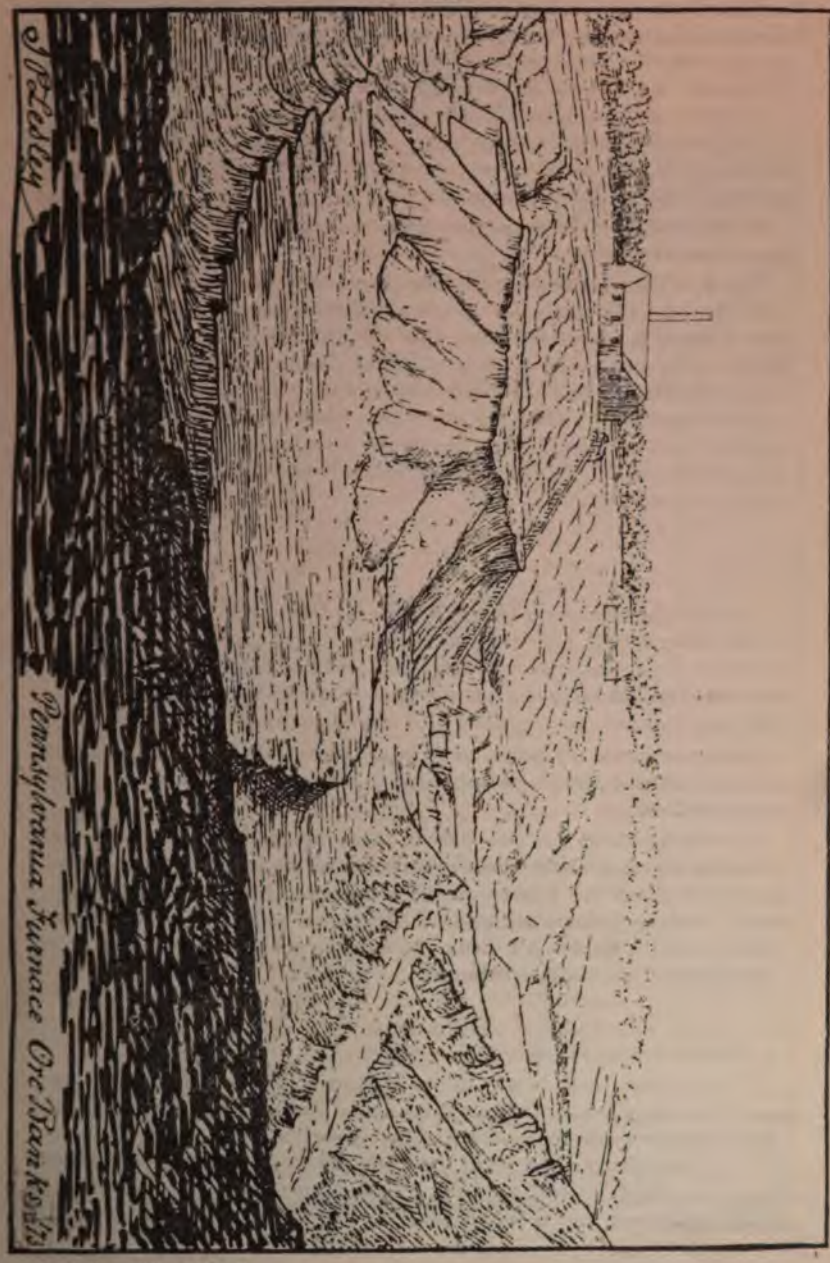
* These lie south of the road, on the large map. Eight yards is taken as the average depth of both, but they may have been worked deeper. Wash ore forms the walls.

† Also south of the road and beyond the limits of fig. 44.

‡ North of the road, at the northeast corner of fig. 44. It has not been worked for years. Wash ore forms the walls.

§ North of the road, and of the Dorsey Bank, fig. 44. Both have fallen shut. Wash ore forms the walls.

FIG. 43.



From the northeasternmost Huntingdon Furnace Diggings to the last Dorsey Digging is a stretch of about 2000 yards, with ore shows filling up the intervals between the banks. There is a maximum breadth of 500 yards. But if half that be adopted for an estimate, we have an area of wash ore here equal to 100,000 square yards, in all respects like that of the Dry Hollow Bank district (on the same range) described above, and representing, at least, one or two millions of cubic yards of ore ground, besides whatever deeper deposits of pipe ore exist.

As in Dry Hollow, so here much lean ore is mingled with the rich, and much dead stripping will be required in places.

There is this distinction: the ore of the barrens, that is the liver-colored and more sandy ore ranges along the northwestern side of the belt of outcrop, up the hill-side; pipe ore characterises the down hill, or southeastern side of the outcrop. The main bank is wholly in the top or wash ore covering, and has merely revealed the principal deposit of rich rock ore and pipe underlying it. Those who worked the pit describe a layer of ore 6 to 8 feet thick as apparently creeping downhill, overturned, and covering itself. What this description means I do not know. The ore makes excellent iron.

It is unnecessary for me to say that the ferriferous limestones described in the above details, and crossing the river (S. W.) into Sinking Valley, carry the ore ground outcrops with them, and that these have been mined to some extent at various places south of Barre Forge, yielding both rich and lean wash ore, and rock and pipe ore, of the same general character.

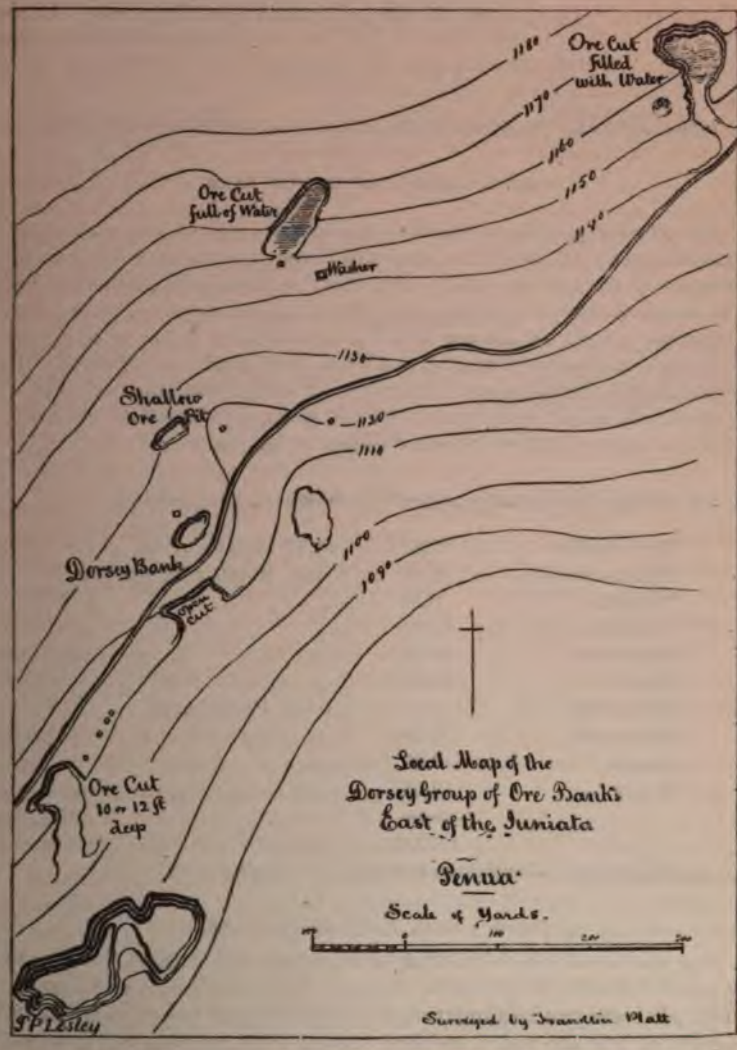
The same statement holds good as to Canoe Valley, although its narrowness does not permit its anticlinal to bring the lowest horison of ore to the surface.

In Sinking Valley the two sides of its dying anticlinal bring the ore-outcrops together about three miles south of the river. The following are some of the ore banks: on the south side, Pine Hill Bank (½ mile from the river); Moore's Pipe Ore Diggings (1 mile); Galbraith's Pipe Ores (1½ mile); Robinson's Bank (2½ miles). On the northwest side are Gentzhammer's and other outcrops.

It is a serious question why mines of Brown Hematite Iron Ore have not been opened on the Juniata River above the mouth of Spruce Creek. This question seems to be answered by my section along the river, fig. 1. It is evident that the horison of the Pennsylvania Furnace or Cale Hollow ores scarcely rises on the back on the Canoe Valley axis to the level of the valley bed, and is immediately carried down again by the syncli-

nal of Canoe mountain. It is then visible in Sinking Creek Valley, as just stated. Whether any large quantities of ore underlie the river bed

FIG. 44.



below Union Furnace and above Spruce Creek Station remains to be determined by future trial shafts along the line of the Pennsylvania Railroad.

INVESTIGATION OF IRON ORES AND LIMESTONES FROM MESSRS. LYON, SHORB & CO'S IRON ORE BANKS ON SPRUCE CREEK, HALF MOON RUN AND WARRIOR'S MARK RUN, IN CENTRE, BLAIR AND HUNTINGDON COUNTIES, PA.

By F. A. Genth.

(*Read before the American Philosophical Society, February 6th*, 1874.)

NO. 1. EAST PENNINGTON BANK.

The greater portion of thirteen specimens, received for examination, was compact, dull, of various shades of brown and had like No. 1 an admixture of dark brown pitchy ore; other portions were porous and had the cavities lined with botryoidal fibrous brown limonite, others were stalactitic. Some of the ore had lost a part of its water of hydration and had changed into turgite and even into hematite. Many of the pieces showed a considerable admixture of manganese minerals, such as wad, minute quantities of pyrolusite and perhaps psilomelane, some contained a large quantity of rounded grains of quartz.

An average of the whole showed the following composition:

Ferric oxide	=	65.88	=	44.77 Metallic Iron.
Manganic oxide	=	6.00	=	4.18 Metallic Manganese.
Cobaltic "		0.34		
Alumina		trace		
Magnesia		0.26		
Lime		trace		
Phosphoric acid		0.22	=	0.097 Phosphorus.
Silicic acid		6.38		
Quartz		7.87		
Water		13.05		
		100.00		

100 Iron and Manganese contain 0.197 Phosphorus.

NO. 2. WEST PENNINGTON BANK.

Five specimens were submitted for examination. The ore was mostly of various shades of yellowish brown to dark hair-brown and without lustre; in some was an admixture of a dark blackish brown ore with subconchoidal fracture and a resinous lustre; some portions had a slight waxy lustre, others were earthy and dull. It was amorphous, but in places the cavities were lined with a coating of brown fibrous limonite. On being breathed upon, it developed a strong argillaceous odor.

An average of the five specimens contained :

Ferric oxide	=	70.93	=	49.65 Metallic Iron.
Manganic oxide	=	0.38		
Cobaltic "		trace		
Alumina		2.81		
Magnesia		0.14		
Lime		0.08		
Phosphoric acid		0.37	=	0.16 Phosphorus.
Silicic acid		4.38		
Quartz		7.91		
Water		13.00		
		100.00		

100 Iron contain 0.32 Phosphorus.

No. 6. Rumbarger Bank.

A sample of ore was taken from a pile alongside of the Bank. It is mostly amorphous and compact, also somewhat porous, and has the cavities lined with a thin coating of fibrous limonite ; the cavities are also coated with red ochre and at times with yellow ochre.

The composition was found to be as follows :

Ferric oxide	=	74.16	=	51.91 Metallic Iron.
Manganic oxide		trace		
Alumina		3.06		
Magnesia		0.24		
Lime		trace		
Phosphoric acid		0.36	=	0.158 Phosphorus.
Silicic acid		6.11		
Quartz		3.94		
Water		12.13		
		100.00		

100 Iron contain 0.30 Phosphorus.

No. 11. Lytle Bank.

The sample received for examination consisted mainly of amorphous compact brown ore, intermixed with fine fibrous limonite. The fibres are from ¼ to ½ of an inch in length and form botryoidal coatings ; sometimes divergent. The outside covered with yellowish ochreous ore.

The analysis gave :

Ferric oxide	=	82.00	=	57.40 Metallic Iron.
Manganic oxide	=	trace		
Alumina	=	1.94		
Magnesia		0.17		
Lime		trace		

Phosphoric acid		0.37	=	0.16 Phosphorus.
Silicic acid		2.98		
Quartz	=	0.44		
Water	=	12.10		
		100.00		

100 Iron contain 0.278 Phosphorus.

No. 14. Bull Bank.

The samples for investigation, five in number, were taken from piles of ore taken out about thirty years ago. One consisted of a beautiful fibrous limonite of a pale hair-brown color and silky lustre, much resembling that from the Lytle Bank, but of fibres two inches in length. The others represented the amorphous ores. They are compact, of various shades of brown, without lustre; they contain more or less cavities, partly filled with ochreous ore of a yellowish or reddish color. The amorphous ores have, on being breathed upon, a strong argillaceous odor.

a. Pure Fibrous Limonite.

Ferric oxide	=	81.48	=	57.04 Metallic Iron
Manganic oxide	=	0.07		
Alumina	=	0.49		
Magnesia, Lime		traces.		
Phosphoric acid		0.08	=	0.035 Phosphorus.
Silicic acid		3.98		
Water		13.90		
		100.00		

100 Iron contained 0.061 Phosphorus.

b. Average of the five Samples.

Ferric oxide	=	74.85	=	52.40 Metallic Iron.
Manganic oxide	=	0.29		
Cobaltic oxide		0.21		
Alumina		2.42		
Magnesia		0.12		
Lime		trace.		
Phosphoric acid		0.24	=	0.105 Phosphorus.
Silicic acid		4.15		
Quartz		5.92		
Water		11.80		
		100.00		

100 Iron contained 0.20 Phosphorus.

No. 15. Pond Bank No. 1.

Two of the four specimens received were of a dark brown porous amorphous ore with very little lustre, more or less mixed with yellowish and reddish ochreous ore; the third piece was of a paler brown and contained small quantities of fibrous ore, the fourth was an ochreous ore of a pale brown and yellowish color. An average of the four samples contained:

Ferric oxide	=	78.68	=	55.08 Metallic Iron.
Manganic oxide	=	0.42		
Cobaltic "		trace.		
Alumina		2.89		
Magnesia		0.20		
Lime		trace.		
Phosphoric acid		0.16	=	0.07 Phosphorus.
Silicic acid		3.17		
Quartz		1.71		
Water		12.77		
		100.00		

100 Iron contain 0.127 Phosphorus.

No. 16. Red Bank No. 1.

Five samples of ore received. It is generally an amorphous compact ore, with a considerable admixture of sand. Some is more porous, and has the cavities lined with fibrous limonite, and more or less filled with clay. Emits, when breathed upon, a strong argillaceous odor. Part of the specimens had lost a portion of their water of hydration.

The analysis of an average sample gave:

Ferric oxide	=	65.44	=	45.81 Metallic Iron.
Manganic oxide	=	0.13		
Cobaltic oxide		trace		
Alumina		5.31		
Magnesia		0.16		
Lime		trace		
Phosphoric acid	=	0.21	=	0.09 Phosphorus.
Silicic acid		6.76		
Quartz		12.78		
Water		9.21		
		100.00		

100 Iron contain 0.195 Phosphorus.

No. 19. Whorell Bank.

Two pieces of a fine brown porous amorphous ore of various shades, between yellowish and dark-brown; some portions showing a slight pitchy lustre; the greater part is dull. Has a strong argillaceous odor when breathed upon.

The analysis of an average sample gave:

Ferric oxide	=	69.71	=	48.80 Metallic Iron.
Manganic oxide		0.46		
Cobaltic oxide		trace		
Alumina		3.37		
Magnesia		0.08		
Lime		trace		
Phosphoric acid	=	0.97	=	0.43 Phosphorus.
Silicic acid		3.51		
Quartz		9.60		
Water		12.30		
		100.00		

100 Iron contain 0.87 Phosphorus.

No. 21. Wrye Bank.

Five specimens received. The ore is amorphous, porous, and scoriaceous. Some of the cavities are lined with a thin coating of fibrous ore. The more compact pieces contain a large admixture of rounded quartz grains.

An analysis of an average sample gave:

Ferric oxide	=	77.00	=	53.90 Metallic Iron.
Manganic oxide		0.36		
Cobaltic oxide		trace		
Alumina		2.15		
Magnesia		0.14		
Lime		0.15		
Phosphoric acid		0.19	=	0.08 Phosphorus.
Silicic acid		2.60		
Quartz		5.53		
Water		11.88		
		100.00		

100 Iron contain 0.15 Phosphorus.

No. 24. Dry Hollow Bank.

Amongst the eight specimens received for examination was one of a beautiful variety of fibrous limonite; the fibres are of about one inch in

length, also divergent and radiating; color dark brown, lustre silky; the other ores were both compact and porous amorphous brown limonites, some with the cavities lined with fibrous ore, others having them filled with ochreous clayish ores. Some of the pieces give a strong argillaceous odor, when breathed upon.

a. Pure Fibrous Limonite.

Ferric oxide	=	**83.13**	=	**58.19 Metallic Iron.**
Manganic oxide	=	**0.15**		
Alumina	=	**0.74**		
Magnesia		**0.09**		
Lime		**trace.**		
Phosphoric acid		**0.50**	=	**0.22 Phosphorus**
Silicic acid		**2.47**		
Water		**12.92**		
		100.00		

100 Iron contain 0.37 Phosphorus.

b. **Average of the eight Specimens.**

Ferric oxide	=	**75.90**	=	**53.13 Metallic Iron.**
Manganic oxide	=	**0.16**		
Cobaltic oxide	=	**trace**		
Alumina	=	**2.44**		
Magnesia		**0.20**		
Lime		trace.		
Phosphoric acid		0.54	=	0.24 Phosphorus.
Silicic acid		2.74		
Quartz	=	7.84		
Water		10.18		
		100.00		

100 Iron contain 0.45 Phosphorus.

No. 24. *b.* Red Bank of Dry Hollow.

An examination of six specimens, showed the general character of the ore to be amorphous, of a dark brown color, and compact; some pieces have cavities lined with yellowish brown and dark brown fibrous limonite; others have rounded quartz grains disseminated through the mass. A portion of the ores has lost part of the water of hydration. The cavities and fractures are frequently coated or filled with a brownish red ochreous ore.

An average sample of the whole contained:

Ferric oxide	=	**80.34**	=	**56.24 Metallic Iron.**
Manganic oxide		**0.52**		

Cobaltic oxide	trace		
Alumina	1.66		
Magnesia	0.13		
Lime	trace		
Phosphoric acid	0.49	=	0.215 Phosphorus.
Silicic acid	3.18		
Quartz	2.63		
Water	11.05		
	100.00		

100 Iron contain 0.38 Phosphorus.

No. 27. Kerr and Bredin Bank.

The three specimens received show the ore to be mostly amorphous and compact, and of various shades of brown, also earthy; some parts are porous and the cavities lined with fibrous limonite, sometimes in botryoidal forms. On being breathed upon, developes a strong argillaceous odor.

The average of the samples contained :

Ferric oxide	=	70.67	=	49.47 Metallic Iron.
Manganic oxide		0.36		
Cobaltic oxide		trace		
Alumina		3.91		
Magnesia		0.26		
Lime		trace		
Phosphoric acid	=	0.19	=	0.08 Phosphorus.
Silicic acid		5.48		
Quartz		6.80		
Water		12.33		
		100.00		

100 Iron contain 0.16 Phosphorus.

No. 28. Hostler Bank.

One specimen of so-called "Pipe Ore." Amorphous, compact and earthy, brown to yellowish brown. Porous. Stalactitic. Coated with yellowish and reddish ochreous ore.

The analysis gave :

Ferric oxide	=	78.58	=	55.01 Metallic Iron.
Manganic oxide		0.08		
Alumina		0.88		
Magnesia		0.54		
Lime		0.30		
Phosphoric acid		0.36	=	0.158 Phosphorus.

Silicic acid		4.25
Quartz	=	2.60
Water	=	12.41
		100.00

100 Iron contain 0.28 Phosphorus.

No. 29. Pennsylvania Bank.

a. Two samples received for examination.

Amorphous brown compact ore mixed with ochreous yellowish or reddish ore; Porous, some of the cavities lined with a very fine coating of fibrous ore.

b. So-called Pipe ore.

Amorphous porous ore, in columnar masses, the cavities filled with ferruginous clay.

c. Quartz grains, cemented by brown amorphous limonite, and disseminated through it, patches of hydrous manganic oxide and perhaps of psilomelane.

a. Average of two Samples.

Ferric oxide	=	81.55	=	57.10 Metallic Iron.
Manganic oxide		0.10		
Cobaltic oxide		trace		
Alumina		1.49		
Magnesia		0.47		
Lime		trace		
Phosphoric acid		0.16	=	0.07 Phosphorus.
Silicic acid		2.98		
Quartz		1.55		
Water		11.70		
		100.00		

100 Iron contain 0.12 Phosphorus.

b. Pipe Ore.

Ferric oxide	=	83.74	=	58.62 Metallic Iron.
Manganic oxide	=	0.31		
Cobaltic oxide		trace		
Alumina		0.33		
Magnesia		0.34		
Lime		trace		
Phosphoric acid		0.14	=	0.06 Phosphorus.
Silicic acid		2.57		
Quartz		0.44		
Water		12.13		
		100.00		

100 Iron contain 0.10 Phosphorus.

c. Sandrock.

Ferric oxide	=	43.65	=	30.56 Metallic Iron.
Manganic oxide, Cobaltic oxide		1.55		
Alumina		2.43		
Magnesia		1.64		
Lime		0.12		
Phosphoric acid		0.27	=	0.12 Phosphorus.
Silicic acid		5.19		
Quartz		36.52		
Water		8.63		
		100.00		

100 Iron contain 0.39 Phosphorus.

OLD CUT NORTH OF GATESBURG. *

A peculiar looking amorphous ore, of a brown and yellowish-brown color, uneven to subconchoidal fracture, dull or of slight waxy lustre, inclining to resinous. It has a strong argillaceous odor when breathed upon.

The composition of the one specimen, which I received for examination, was found to be :

Ferric oxide	=	71.63	=	50.14 Metallic Iron.
Manganic oxide, Cobaltic oxide	=	0.53		
Alumina		4.63		
Magnesia		0.37		
Lime		trace		
Phosphoric acid	=	1.67	=	0.73 Phosphorus.
Silicic acid		3.69		
Quartz		4.64		
Water		12.84		
		100.00		

100 Iron contain 1.43 Phosphorus.

The amount of metallic iron in the calcined ores is as follows :

No. 1.	East Pennington Bank	51.49 per cent.
" 2.	West Pennington Bank	57.07 "
" 6.	Rumbarger Bank	59.08 "
" 11.	Lytle Bank	65.30 "
" 14.	Bull Bank—*a*, fibrous ore	66.25 "
" "	" " —*b*, average	59.41 "

*Mr. Platt's Station 568.

No. 15.	Pond Bank, No. 1	63.14	per cent.
" 16.	Red Bank, No. 1	50.46	"
" 19.	Whorell Bank	55.64	"
" 21.	Rye Bank	61.17	"
" 24.	Dry Hollow Bank—*a*, fibrous ore	66.82	"
" "	" " " —*b*, average	59.15	"
" 24*b*.	Red Bank of Dry Hollow	63.23	"
" 27.	Kerr and Bredin Bank	56.43	"
" 28.	Hostler Bank	62.80	"
" 29.	Pennsylvania Bank—*a*, average	64.67	"
" "	" " —*b*, pipe ore	66.71	"
" "	" " —*c*, sandrock	33.44	"
Ore from Old Cut N. of Gatesburg		57.52	"

All these ores were examined for Sulphur and Sulphuric acid, but not a single one gave a decided reaction for either. They were also examined for Titanium, Chromium, Vanadium, and other metals, but with negative results.

Their only constituent, which has an injurious effect upon the quality of the iron, produced from the same, is phosphoric acid; most of them, however, contain it in too small a quantity to be of much harm. Only two of the samples contain it in a larger proportion.

For better comparison, I will arrange the amounts of Phosphorus which would be contained in 100 parts of iron, provided no loss of either would be sustained:

Fibrous ore of Bull Bank	0.06	Phosphorus.
Pipe ore of Pennsylvania Bank	0.10	"
Average ore of " "	0.12	"
Pond Bank, No. 1	0.127	"
Wrye Bank	0.15	"
Kerr and Bredin Bank	0.16	"
Red Bank No. 1	0.195	"
N. E. or Upper Pennington Bank	0.197	"
Average of Bull Bank	0.20	"
Lytle Bank	0.278	"
Hostler Bank	0.28	"
Rumbarger Bank	0.30	"
S. W. or Lower Pennington Bank	0.32	"
Fibrous ore of Dry Hollow Bank	0.37	"
Red Bank of Dry Hollow	0.38	"
Sandrock of Pennsylvania Bank	0.39	"
Dry Hollow Bank	0.45	"
Whorell Bank	0.87	"
Old cut N. of Gatesburg	1.43	"

Of all the ores submitted for examination only two appeared to be in a

sufficient state of purity to throw light upon their constitution, as they were crystalline, and free from visible impurities. For this reason they were examined separately.

Taking into consideration only their principal constituents, viz: Ferric oxide, Silicic acid and water, the question arises, in which form the silicic acid is present, as it is undoubtedly in chemical combination with the ferric oxide and *not* in the form of a mechanical admixture of sand. If pieces of these fibrous limonites are placed into strong chlorhydric acid, all the ferric oxide will be extracted, and the silicic acid will remain in the shape of the original pieces, of a snow-white color and fibrous structure. The only hydrous ferric silicates, which are known, are Anthosiderite and Degeroeite. The former is a crystalized mineral, which has a composition, represented by the formula $2Fe_2O_3$, $9SiO_2+2H_2O$. It is very probable that, although observed in its pure state only at one locality, it occurs frequently as an admixture with other iron ores.—If we calculate for the 3.98 per cent. of silicic acid in the fibrous mineral from Bull Mine, the requisite quantities of ferric oxide and water, we find 2.36 per cent. of ferric oxide and 0.26 per cent. of water, making an admixture of 6.60 per cent. of anthosiderite. The atomic ratio between the remaining 79.12 per cent. of ferric oxide and 13.64 per cent. of water is 1 : 1.53 or very near 2 : 3, showing the hydrous ferric oxide to be limonite $= 2\ Fe_2\ O_3,\ 3\ H_2\ O$.

If in the same manner we examine into the composition of the fibrous mineral from the Dry Hollow, the 2.47 silicic acid require 1.46 per cent. ferric oxide and 0.17 water, giving an admixture of 4.10 per cent. of anthosiderite.—The atomic ratio between the remaining 81.67 per cent of ferric oxide and 12.75 per cent. of water is 1: 1.4, which also shows the ferric hydrate to be limonite, which, however, has already lost a small part of its water.

The above analyses show besides the mechanically admixed rounded grains of sand, which I distinguish as "quartz," a considerable quantity of silicic acid, which is in chemical combination, probably as a hydrous ferric oxide. But as it is impossible to say what the true character of this mineral may be, whether anthosiderite, or degeroeite a silicate of the composition $Fe_2\ O_3$, $2SiO_2+3H_2O$ or a species not yet known in its pure state, suffice it to say that all these ores are mechanical mixtures of limonite with hydrous ferric silicate and minute quantities of hydrous ferric phosphate, perhaps dufrenite or cacoxenite; some of the ores contain besides these, small quantities of manganese ores, mostly the so-called "bog-manganese" or wad, but also pyrolusite and psilomelane.

It is a very remarkable fact that, although these iron ores are to a great extent at least, the result of the decomposition of limestones and by them precipitated, that almost the entire amount of lime has been washed out of them and only traces are remaining; of the second constituent of the limestones, the magnesia, a somewhat larger quantity is left behind, owing undoubtedly to the lesser solubility of its carbonate in carbonic acid water.

Of the limestones only a few typical varieties have been more fully investigated, especially those from the Hostler and Pennsylvania Banks.

Limestone at head of Hostler Bank.

It has a fine crystalline granular structure and is mottled, whitish and grey; the surface is coated with ochreous argillaceous iron ore.

A pure specimen from which the iron had been carefully removed, contained:

Carbonate of Iron	=	0.80	=	0.39 Metallic iron.
" " Manganese	=	0.19	=	
" " Magnesia	=	35.19	=	16.76 Magnesia.
" " Lime	=	59.44	=	33.28 Lime.
Quartz and Silicic Acid		3.84		
Alumina		0.54		
		100.00		

The atomic ratio between Magnesia and Lime is 1: 1.4, which is the composition of some of the "pearlspar" varieties of dolomite.

Limestone in Hostler Bank.

It lies four feet thick over 33 feet of pipeore. It has an ash-grey color and a very fine grain, which is hardly perceptible to the naked eye; very friable. Its composition was found to be:

Carbonate of Iron	=	0.50	=	0.24 Metallic Iron.
" " Manganese	=	0.24		
" " Magnesia	=	42.52	=	20.25 Magnesia.
" " Lime	=	51.82	=	29.02 Lime.
Quartz and Silicic Acid		4.33		
Alumina		0.42		
Water		0.17		
		100.00		

The atomic ratio between Magnesia and Lime is 1: 1, which shows it to be a true dolomite.

Upper Limestone from Pennsylvania Bank.

Dark grey compact, slightly crystalline

The analysis gave the following results:

Carbonate of Iron	=	1.31	=	0.63 Metallic Iron.
" " Manganese	=	0.18		
" " Magnesia		3.98	=	1.90 Magnesia.
" " Lime		72.67	=	40.69 Lime.
Quartz and Silicic Acid		18.05		
Alumina		3.81		
		100.00		

The atomic ratio between magnesia and lime is 1 : 15.

Limestone in the Pennsylvania Bank.

Pale ash grey, very finely crystalline, rough to the touch like rotten stone, very friable and easily falling to powder.

Its composition was found to be:

Carbonate of Iron	= 0.45	= 0.22	Metallic Iron.
" " Manganese	= 0.06		
" " Magnesia	42.39	= 20.19	Magnesia.
" " Lime	51.25	= 28.70	Lime.
Quartz and Silicic Acid	5.03		
Alumina	0.82		
	100.00		

The atomic ratio between Magnesia and Lime=1 : 1, shows it to be a true dolomite.

Another Variety of Limestone in the Pennsylvania Bank.

Yellowish grey, soft, rotten, feels rough to the touch, sandy; crystalline; has a laminated structure. Its analysis gave:

Carbonate of Iron	= 1.18	= 0.57	Metallic Iron.
" " Manganese	trace		
" " Magnesia	35.51	= 16.91	
" " Lime	45.73	= 25.61	
Quartz and Silicic Acid	15.83		
Alumina	1.75		
	100.00		

The atomic ratio between Magnesia and Lime=1 : 1.08 proves it also to be a true dolomite.

It is remarkable that the limestones and dolomites, of which I give the analyses, contain almost the entire amount of silicic acid as quartz, only a small quantity is present as soluble silicic acid and in combination with alumina. If the limestones and dolomites are dissolved in acid, the quartz remains often as a scoriaceous mass or in irregular sandy but not rounded or water-worn grains; sometimes it forms large coherent slaty masses in the limestone, frequently filled with minute cavities, previously occupied by rhombohedral crystals of dolomite. Similar pieces found in the Pennsylvania Bank are white, like porcelain and show the same cavities of rhombohedral crystals. Other varieties of limestone in the Pennsylvania Bank have a still greater admixture of quartz and are a real calciferous sand rock.*

University of Pennsylvania, January 23d, 1874.

* These analyses summed up about 100, most of them a little above, one or two a little below, but all within the limits of unavoidable error; for better comparison I thought it advisable to calculate them for 100.00, from the actual result obtained. (F. A. Genth.)

ANALYSES* OF PENNSYLVANIA PIPE, AND PENNINGTON ORE.

3, DEVONSHIRE TERRACE, KENSINGTON, LONDON, W.,
January 5*th*, 1871.

DEAR SIR:—Herewith I beg to forward you the results of my analysis of the two samples of ore, marked, respectively, "Pipe Ore" and "Pennington Bank."

The whole of the samples were intimately pulverized together in each case; they contain

	PIPE ORE.	PENNINGTON BANK.
Silica	10.84	5.42
Peroxide of Iron	73.18	79.05
Protoxide of Iron	.75	
Aluminia	2.51	1.29
Oxide of Manganese	traces.	.11
Carbonate of Lime	.20	
Carbonate of Magnesia	1.20	Magnesia. .11
Phosphoric Acid	.17	.04
Combined Water	9.09	10.57
Moisture	1.81	3.55
Sulphur	.05	
	99.80	100.14
Metallic Iron	51.81	55.34
" " exclusive of Water	58.25	64.35

Both these samples are rich iron ores, sample "Pennington Bank" being nearly pure brown hematite. The pipe ore is a harder ore than "Pennington Bank" ore.

I consider both samples of ore adapted for the manufacture of Bessemer Pig.

Believe me to remain, yours, very faithfully,

EDWARD RILEY, F. C. S.,
Metallurgist, Analytical and Consultiny Chemist.

ANALYSIS OF "PIPE ORE," "KERR & BREDIN" AND PENNINGTON BANK ORES, BY CH. ALDENDORF, SUB-DIRECTOR OF THE GEORGE-MARIEN HUTTE HIGH FURNACES, MARCH 9, 1872.

		PIPE ORE.	KERR & BREDIN.	PENNINGTON.
Water		11.190	10.540	12.340
Insoluble Residue,	$Si\,O^2$ / Al^2O^3	5.120	13.400	5.450
Oxide of Iron,	F^2O^3	82.050	73.560	79.450

* These analyses by an English chemist of well known reputation, especially entrusted by Mr. Bessemer with his numerous and important analyses, are here added for comparison.

		PIPE ORE.	KERR & BREDIN.	PENNINGTON.
Alumina,	Al^2O^3.....	1.650	2.840	3.096
Oxide Manganese,	Mn^2O^3....	0.270	0.190	0.440
Chalk,	CaO.....	0.370	0.460	0.440
Magnesia,	MgO.....	trace.	trace.	trace.
Phos. Acid,	$P.O^5$.....	0.080	0.280	0.064
Sulphuric Acid,	$S.O.^3$.....	trace.	trace.	trace.
		100.730	101.270	101.280
Per cent. Metallic Iron.....		57.435	51.492	55.61
Phosphorus in 100 Iron.....		0.061	0.238	0.053
Per ct. Iron, excluding Water,		64.150	56.075	62.540

"The Pipe and Pennington Ores if melted together would make a very superior Bessemer Iron. The Kerr & Bredin *alone* an inferior Bessemer Iron. A separate analysis, however, of Kerr & Bredin shows that its Phosphorus is concentrated in the Clay thereto attached, and it may be that this Ore may be made available for Bessemer Pig, by proper treatment before smelting."

ANALYSIS OF PENNSYLVANIA FURNACE LIMESTONE BY OTTO WUTH, CHEMIST, PITTSBURGH, Pa.

From Quarry near the Furnace—a grey crystaline Stone :

Silicic Acid.....	5.08
Alumina.....	1.34
Carbonate of Iron.....	.69
" " Lime.....	91.53
" " Magnesia.....	1.31
Sulphate of Lime.....	trace.
Organic Matter.....	.05

From Ore Bank Rail Road Cut — a partly crystalline drab-colored stone :

Silicic Acid.....	4.93
Alumina.....	.24
Carbonate of Iron.....	.87
" " Lime.....	84.66
" " Magnesia.....	8.98
Sulphate of Lime.....	.11
Organic Matter.....	.21

Gray Crystalline Stone, sou h side of road from Half Moon Run to Hostler Bank, near the Half Moon Run.

Silicic Acid	2.71
Alumina	.11
Carbonate of Iron	1.80
" " Lime	83.91
" " Magnesia	11.14
Sulphate of Lime	.12
Organic Matter	.21

Smooth Grey Stone from north side of road near the foregoing:

Silicic Acid	6.87
Alumina	1.35
Carbonate of Iron	.75
" " Lime	86.42
" " Magnesia	4.24
Sulphate of Lime	.21
Organic Matter	.16

Mining Methods.

It will be seen from the above descriptions, that mining operations have been mostly carried on in this region in an irregular and primitive style. I requested Mr. John W. Harden to give me the benefit of his large and varied experience as a mining engineer and superintendent, both in the English and in the American collieries and iron mines, in stating what ought to be the most economical mode of entering on and exhausting the Nittany Valley limestone deposits. His recent success in increasing the export of limonite from Pinegrove Furnace banks south of Carlisle, by a judicious application of a system of regular approaches, justifies me in placing a high value on any practical suggestions he has to offer respecting similar deposits.

He therefore visited the Pennington, Dry Hollow, Kerr & Bredin, Pennsylvania Furnace, and other Banks above described; and the following extracts from his report will show that there is but one conclusion to arrive at, and that a very simple one; viz., that the system to be almost universally adopted is that by open-cuts, approached from the direction of the railway, at the lowest possible levels, and worked to the right and left, in advancing slopes, one above the other; that the deep rich-ores should be worked at the same time with the upper wash-ores, or not greatly in arrear of them, so that the wash-ore thus won may pay the expenses of uncovering the richer lower ores; and that where surface water is scarce, bore-holes should be sunk to serve the double purpose of exploration and water supply.

Whether additional and larger furnaces be erected in the Valley, or whether the ores be sent by rail to the Iron Works in Eastern and

Western Pennsylvania, in both contingencies an exploitation of ore must be provided for, amounting annually to many hundred thousand tons per annum.

The largest mining operation in the Valley being that of the Pennsylvania Furnace, Mr. Harden takes the account book of the works at that point for a practical basis of calculation of the cost of exploitation. It is evident that mining conditions through the Valley are very similar. No system of between-rock mining will be required for many years. But exploring drifts and shafts will be necessary, and under-cutting where the clays are destitute of ore and too thick to remove. Most of the work however must be done in open cuts of great extent, with simple machinery for obtaining water and washing the entire mass of ore-ground to the very bottom, or to the deep rock-ores, which can be quarried and used without washing. In many cases the rock-ore, and in some cases the clay-ore, can be followed downward between solid masses of limestone rock ; but this must be done in connection with the open-cuts.

At the Pennington Banks there appear to be from 50 to 80 feet of wash-ore and clays overlying from 8 to 16 feet of rock-ore.

At the Dry Hollow Banks there is a stripping at the surface from 5 to 15 feet deep containing but little ore ; then wash-ore with sands and sandy clays to a depth of 20 or 30 feet before reaching rock-ore.

At the Hostler Banks a top stripping of 5 feet or more, covers 50 to 60 feet of wash-ore in clay, under which lie the pipe-ores, which are reported as having been in one place over 40 feet deep ; limestone layers covering and dividing the mass. The miner who sunk the last shaft informed Mr. Harden that it went down 60 feet through wash-ore, 5 feet through solid limestone, and 7 feet in pipe-ore on one side of it, and wash-ore on the other side ; water stopping further sinking.

At the Pennsylvania Furnace Banks, the entire mass from the surface to the floor of the quarry is wash-ore mixed with clay and sand. The whole of this mass has been washed. "In one place a 13 feet face of excavation gave 3 to 4 feet of surface soil and sienna-colored sandy-wash, the remainder below it being a sandy, whitish ochre, and sienna colored clay, streaked and marbled with red and brown, and some, not large lumps of ore. Scattered through the whole, in considerable quantity in some places, are small pieces of quartz which are picked out after the ore has passed over the trays. In another part of the diggings this quartz, from the size of shot to lumps 3 or 4 inches thick, is scattered through the mass.* Some masses of this quartz, of one or two cubic feet in size, lie about the quarry.

"In a deeper part of the diggings where the face of iron and work measures 45 or 50 feet, in two heights of 15 and 30 to 35 feet, now being moved to the inclined plane for washing, the face is made up of sand and various colored clays holding ore, all of which is washed. Limestone appears at the bottom and pipe-ore has been found underneath it."

* Mr. Harden gives an analysis of this quartz : Water, 0.50, Silica, 96.00, Iron and alumina, 1.76, undetermined, 1.68.

Mr. Harden advises that the stripping of wash-ore be not carried on far in advance of the lifting of the rock and pipe-ore at the bottom; because, even where the farming interest does not interfere, such a plan "disturbs the equal distribution of dead work" and prevents the rejection of those parts of the stripping which do not pay well for washing. Ample room ought to be got early for lifting the entire mass of rich bottom ores.

"With a good roomy open cutting the mass of wash ore should cost no more to move than so much ordinary excavation." "The ore-earth is loaded into cars carrying 29½ cubic feet, led by horses to the foot of the incline, 300 to 500 feet, whence it is lifted 37 feet on a grade of 14°, to a level with the washers, by a 12 inch cylinder steam engine, 2 foot stroke, and pair of 8 foot drums. The car load is again dragged 150 feet and dumped into the washing troughs, in which revolve three Archimedian screw-propeller shafts 20, 26, and 26 feet long respectively. The shafts are of decagonial timber, 15 inches in diameter on the facets of which are screwed cast iron blades. The ore travels 72 feet, and is dropped into two classifying screens, the sand and mud being floated off to the settling dam. The screens have ¼ inch and $\frac{1}{16}$ inch meshes. The ore falls on sheet iron trays where the quartz is picked out. The washers are driven by a 16 inch cylinder engine, 54 inch stroke; the steam being generated in two double flue boilers 30 feet long and 40 inches in diameter. The water arrives by an aqueduct 2000 feet long mounted on tressels arranged along the top of the hill. It is fed by a pipe of 12 inch diameter laid up the hill side to a vertical height of 110 feet above a double Worthington pump with 20 inch steam and 15 inch water cylenders; the fall of reservoir is 1 foot in 250. The steam boilers for the pump are also 30 feet long by 40 inches diameter, driving also a Blake stone-crusher, used for the flux.

The digging of the ore is said to be done by contract at half the price of ordinary earth.

Six cubic yards of earth has been found to produce an average of one ton of washed ore, the diggers being paid 16 cents per car-load of 29.58 cubic feet = 23.67 of solid earth. A cubic yard will therefore cost 18¼ cents and a ton of ore $1.09. The ore delivered at the furnace costing $2, there remains 91 cents for leading, raising, washing, picking and delivery.

But the great economy of this operation can be duly realized only by remembering that the earth washed and ore utilized is that which under any other circumstances would be dumped on one side as "spoil," and as such chargeable against the lower and better ore. "Seeing also that in so utilizing this (otherwise) refuse just so much dead charge is removed, we are led to anticipate a less costly production of the ore which follows it; and we have ground for contemplating equally favorable results at other banks, the same course being pursued."

The Furnace stands under the high bank of Spruce Creek, with its

village occupying the upper slopes on both sides of the Creek, and the farms stretching south and east to the foot of the mountain. It is a stack 43 feet high, 9½ feet across the boshes, 48 inch tunnel, slope of boshes 68°, hearth 5½ feet high, 48 inches wide at top and 30 inches at the bottom, with two cold-air tuyeres, fed from blowing-tubs 6.4 long, driven by a 16 inch cylinder engine, 4½ feet stroke. A Cameron blast 22 inch steam cylinder and 6 × 5 feet blowing-tub is held in reserve. Steam is generated in three 30 feet cylinders, 42 inches in diameter, fed with Creek water by a No. 4 Cameron steam pump, with a No. 8 Earl steam pump in reserve. Another steam-engine drives three lathes.

The uniform yield of the furnace has been 100 tons per week. It is now changed to hotblast, by the recent erection of a Pleyer oven 17×5×2½ feet, with six tiers of pipes, in a building 17 × 12.

THE FOSSIL ORE BELT.

On the north-west flank of the Bald Eagle Mountain the Medina Red Sand-stone and the Clinton Red Shales and Marls, all standing vertical at the out-crop, (see figs. 1, 2, 3, 4,) bring up to the surface the Upper Soft and Lower Hard Fossil Ore Beds, long and extensively worked at Frankstown in Blair County, 15 miles south of Tyrone City.

One or other of these out-crops may be noticed at three points marked on the west flank of the Bald Eagle Mountain in the Large Topographical Map accompanying this report.

On a separate and smaller Map of the same Mountain, continued to the south of Tyrone under the local name of Brush Mountain, both out-crops may be seen in the same relative positions.

On the sheet containing this smaller Map are three geological cross sections, two of which show the vertical attitude of the fossil ore-beds at Tyrone City Gap, and the third their more inclined attitude at Dysarts Mine, at the south limit of Lyon, Shorb & Co.'s lands, four miles south of Tyrone City Gap. By the time the beds reach Frankstown they get to be nearly horisontal. Beyond Hollidaysburg they become vertical again, owing to the Morrison's Cove fault (which exactly simulates the Bellefonte fault), and again they die away to the horisontal on Dunnings Creek. At Bedford they are again vertical; and so they alternately stand and fall through Virginia and Tennessee.

In the other direction from Tyrone City, north-eastward, the vertical attitude of the fossil ore-beds is pretty well maintained for forty miles; past Bellefonte, Lock Haven and Wilkesbarre, to Muncy, where they fold almost horisontally around the east end of the Bald Eagle (Muncy) Mountain.

Wherever the out-crops of the fossil ore-beds of No. V. have been examined, along their out-crops to the north-east of the Tyrone neighborhood, they have been found too thin to work; at least, for cold blast

charcoal furnace use, in the presence of the magnificent deposits of brown hematite in the Lower Silurian Limestones (No. II).

But from the neighborhood of Tyrone City Gap southward, past Frankstown, Holidaysburg and Bedford, they have paid well for mining, and continue to furnish an apparently inexhaustible fund of 30 per cent. to 40 per cent. ore to the large coke-furnaces of Blair and Cambria Counties.

By comparing my larger topographical Map with Mr. Lowrie's Land Map it will be seen that the out-crops of Fossil Ore on Lyon, Shorb & Co.'s lands range in an unbroken line from the Abner Webb tract to the Shippen tract, a distance of ten and a half (10½) miles, and always in an attitude nearly or quite vertical; falling off at the south end to 60° W. N.W.

The geological order of the beds at Frankstown, where they are extensively mined, is by careful measurement as follows:

Red Shale of No. V. (Clinton Group.)
e. Soft fossil ore, small single bed, 3 to 8 inches.
Red Shale, 100 feet.
d. Soft fossil ore-bed.
Yellow ochre, 10 feet. } In all 25 to 40 inches.
c. Soft fossil double ore-bed.
Red shales and some thin sand stones, 400 feet.
Chocolate slates, 20 feet.
b. Frankstown main soft ore-bed, 14 to 16 inches.
Grey and dove colored slates, 17 feet.
Red sand stones and shales, 155 feet.
a. Hard fossil ore-bed, about 10 feet.
Red and grey sand stones of IV, to the crest of the Mountain, say 700 feet.

a. HARD FOSSIL ORE BED.

This is a layer of sand charged with peroxide of iron and full of minute fossil shells and encrinal discs the calcareous parts of which are dissolved away. It forms a bed of ore yielding by analysis about 30 per cent. of iron; and in the furnace 3¼ to 3½ tons of it make a ton of metal, always cold-short, and therefore chiefly valuable when mixed in proper proportions with other ores.

Prof. Persifor Frazer's analysis of specimens taken from the middle bench in Dysart's Mine recently opened (see smaller Map), made for me in his laboratory in the University of Pennsylvania, is as follows:

Specific gravity: 3.26.

Sesquioxide of iron	38.48	Metallic iron 30.34
Protoxide of iron	4.37	
Silica	37.99	
Alumina	9.56	
Lime	1.08	

Magnesia	a trace.
Alkalies	2.54
Phosphoric Acid	1.48
Sulphur	0.05 (trace.)
Loss by ignition	4.50
Total	100.00

At Howard Furnace the ore was analysed, &c., some years ago and found to contain 28 per cent. of iron.

The bed was here found standing at 80° towards the N. N. W. and only 22 inches thick.

In the end of the Mountain south of Tyrone City this bed has been recently opened at a height of 260 feet (by barometer) above the Juniata River, the slope of the surface being 40°, and the pitch of the bed at the out-crop 60° into the mountain (S. E). But this is due to the creep of the out-crop down hill. The body of the bed stands vertical.

There is 6½ feet of rock-ore between overlying sandy shales and underlying foot shales; only the upper 22 inches of the bed in six plies is here workable.

At Dysart's, 4 miles south of Tyrone city, a tunnel 20 feet long, 575 feet (bar.) above the level of the Juniata, strikes the bed pitching 50° to 60° (at the two headings, right and left)* towards the N. 50° W. About six feet of ore is here mined and sent to Pittsburgh, *via.* Tipton Station on the Pennsylvania Railroad at the foot of the mountain opposite the mine.

At the heading in Oct. 1873 was seen the following order of layers:

Fossil ore, at mouth of tunnel in soft rotten shale			6	inches.
Rock in tunnel	16	feet.		
Hard lean fossil ore	1	"	5	inches.
Hard fossil ore	2	"	10	"
Clay parting			2	"
Hard fossil ore	2	"	0	"

Soft shale floor rotted into compact mud, the water bearing stratum.

In October 1873 a Pittsburgh furnace was doing good work mixing ¼ of this Tipton (Dysart) ore with ¾ of a very pure ore, deficient in silica and alumina, which deficiency the hard fossil ore supplied; and that, without any marked prejudice to the run of the furnace as to quantity, although two-thirds of the Tipton ore went below 40 per cent. and one-third below 30 per cent. of iron; the Tipton ore making good cinder, and thus relieving a part of the pure ore from that duty. The quality of the pig-metal produced after the mixture was adopted remained unchanged.

This aspect of the future utility of this lowest deposit *a* of the fossil ore series of N. V. is important.

At Frankstown the bed sometimes reaches a thickness of ten feet.

* Higher up, red sandstone at the surface dips 78°.

On the southeast flank of Tussey Mountain at R. H. Powell's mines, ten miles southeast of Frankstown, the same bed varies from 15 to 25 feet in thickness, and shows three well-marked benches, an upper and a lower of sandy rock ore, and a middle bench, 5 or 6 feet thick, of soft rich fossil ore, which is mined by the Cambria Iron Co. and transported in large quantities ninety (90) miles by railroad *via*. Huntingdon and Tyrone city across the Alleghany Mountain to the Company's furnaces at Johnstown in Cambria County, for mixing with coal-measure ores (mined back of the furnaces) and high grade ores from Lake Superior and Missouri.

This is another practical evidence of the importance of this deposit to the pig-metal make in America.

The bed is absolutely continuous and uninterrupted. Its outcrop can always be found at a well-defined elevation on the flank of the Upper Silurian Mountain, and about two-thirds of the distance from the base towards the summit. But the bed is very variable in thickness even in distances of a few hundred yards, and ought to be opened in many places along its run of nearly eleven miles through Lyon, Shorb & Company's lands, before any extensive mining plant is made.

Its solid contents *above water level* is very large. Southwest of the Tyrone gap it contains above water level from one to three million cubic yards of ore, according as its thickness varies from three to nine feet. Northeast of the gap, it contains one to two millions more, allowing for the probable general thinning of the bed in that direction; but as experience has taught us that sections of its outcrop are very likely to show an exceptionally great thickness, the estimate may be indefinitely increased.

Along the whole 10½ miles of outcrop it runs parallel to and within less than a mile of first-class railways, (the Pennsylvania Railway, and the Bald Eagle Valley Railway,) which offer facilities for distributing it to furnaces in northern, eastern, and western Pennsylvania. It is also exposed on both sides of the Tyrone Gap, on the line of the Pennsylvania Railroad, so that a main gangway a mile long can be driven in just high enough above grade to allow of shutes on a siding.

This bed in its descent beneath the surface and water level probably suffers no such change as that which the soft fossil ores (to be next described) suffer, and it can therefore be mined hereafter to an indefinite distance downwards by shafts and slopes. This fact adds many millions of tons of available ore to the estimate given above.

Soft Fossil Ore Beds.

About 40 inches of this ore may be looked for along its outcrop wherever the deposit *c*, *d*, is in good order. Sometimes its three beds are near enough to mine in one gallery. Oftentimes one or another of them is wanting. Often they lie ten, twelve or more feet asunder. The variations are frequent and rapid. Several hundred feet beneath the triple bed *c*, *d*,

occurs at Frankstown bed *b*, so thick as to be called *there* the main bed. A hundred feet above the triple bed *c*, *d*, at Frankstown is still another layer a few inches thick.

It is important to note the order in which these deposits occur to the explorer descending the mountain side from the outcrop of the hard fossil ore, because it is very evident, that the occasional openings made along the range on one or other of the three principal soft fossil ore outcrops, viz. *b;—c, d;—e;*—are very misleading. The Bald Eagle Mountain was for many years condemned by geologists as destitute of *workable* fossil ore, because the number of beds was not known; no comparison of localities was made; no complete section down the mountain slope, at any one place. Since the different beds vary in thickness constantly and rapidly, and apparently under a law which may be rudely stated thus: *when one bed thickens it is at the expense of the others*, as if there was but a certain quantity of iron at command and sometimes one bed would get more than its share, and sometimes another,—it follows that the value of any tract on the mountain side can be determined only after a thorough trial of all three (five) outcrops of soft fossil ore has been made; and in no instance has this been done, in the range of 10½ miles upon the Lyon, Shorb & Co.'s lands, nor between them and Frankstown, nor east of them.

Every road decending the west face of the mountain exposes one or more of these outcrops; the highest (lowest geologically) being always 50 or 60 yards below the hard fossil outcrop, where the sandstones of the crest commence.

The red sandstones of the crest and first steep pitch of mountain side between the crest and the hard fossil outcrop, send a multitude of fragments down over the soft yellow and red shales forming the middle slope of the mountain, and under these the soft fossil outcrops lie concealed. The gentle foot-slopes of the mountain are occupied by limestones, marls and red shales.

One of the soft fossil beds has been opened 1,300 yards northeast of Tyrone city, as shown on the Brush Mountain map accompanying this report, at an elevation of 370 feet above Railroad grade. A limestone bed crops out 70 yards down the slope (above it geographically) at 320 feet above railroad grade. The ore-bed is opened by a tunnel and "is 18 inches thick," including some thin layers of ferriferous fossil limestone. It stands "vertical," or overturned slightly so as to dip into the mountain in a direction S. 48° E.

Nothing is known of the other beds.

Experience at Danville and Bloomsburg in Eastern Pennsylvania has proved that the soft fossil ore can be extensively mined when only 16 or 18 inches thick (on a general average of the workings) as may be seen by reference to the very important chapter written on this subject by Prof. H. D. Rogers at page 440 and onward in the first volume of the Final Report of the Geology of Pennsylvania. Experience at Franks-

town has been similar. But at these localities the gentle dip has its bearing upon the economy of mining, and perhaps upon the question of depth to which the *softening of the fossil limestone into soft fossil ore* has gone. I say perhaps, because it was Mr. Rogers' fixed opinion that the fossil ore would not be found fit for mining operations along those runs of outcrop where the beds stood at a steep angle, or vertical. This opinion must be set aside, since the long horisontal gangways, at water level, at Bedford, have yielded the soft ore in a perfect condition at a depth of several hundred feet vertically beneath the outcrop.

It is safe therefore to expect, in the ten or eleven miles of ore-range to find one or more of the beds at other place, of workable thickness and in good condition, with an average breast above water level of from 200 to 400 feet. If only 18 inches of proper ore can be got from all five beds, along the whole 10½ miles, there exists practically 925,000 cubic yards of the ore above water level. If the average thicknesses mined at Frankstown extend to Tyrone city, then there exists in the four miles of mountain side along the Pennsylvania Railway alone, and above water level alone, 42 to 64 inches $\times$ 7,040 $\times$ 100 = 2,464,000 to 3,731,-200, = say three millions of cubic yards of ore.*

It is not to be expected that all the beds can be mined at any one place; but a million of tons of good merchantable soft fossil ore to be won from the southwest division of the Lyon, Shorb & Co.'s lands, *above water level* cannot be an unreasonable estimate.

This ore is greatly esteemed and extensively used by all the furnaces of Pennsylvania which can get it. as an enriching flux for leaner ironstones, and as a fusable mixture for refractory highgrade magnetites. At Frankstown and elsewhere it has furnished the greater part of the burden; and at other furnaces it is mixed in large proportions with brown hematites. It always holds lime in the condition of undissolved fossil shells, and works kindly with the sandy rock fossil (*a*) of the same (Upper Silurian) formation.

NOTE. March 4, 1874. Mr. Stewart has just made the important discovery, by running-in horisontally a monkey-drift, west of Tyrone Station, that four layers of soft fossil ore occur there in a space of seven feet, measuring respectively 18, 10, 5 and 2 inches. This affords nearly the normal quantity of 40 inches, and more than the quantity required for profitable exploitation. It is an especially important trial work, inasmuch as it casts an encouraging light on the untested and hitherto despised range of outcrop east of Tyrone. J. P. L.

* Mr. Rogers' formula of 50,000 tons of ore from each running mile of outcrop was based upon his then assumed maximum depth of no more than 30 yards for the soft ore in a stratum 18 inches thick, two tons of ore going to a cubic yard.

ON A SUPPOSED ALLOTROPIC MODIFICATION OF PHOSPHORUS.

By Prof. Edwin J. Houston.

(*Read before the American Philosophical Society, January* 16, 1874.)

In connection with Prof. Elihu Thomson, of the Artizan's Night School, the author has undertaken a series of experiments, resulting, it is believed, in the discovery of a new allotropic modification of phosphorus.

It is well known that when phosphorus is boiled in strong solution of potassium hydrate, and then allowed to cool slowly, it retains its liquid state for some time; but that if shaken, or touched with a sharp point it instantly solidifies.

We believe that in the cases heretofore observed, the property of retaining the liquid state is probably owing to the admixture with the ordinary phosphorus of an allotropic modification, having the property of retaining its liquid state indefinitely, and that, therefore, if this modification were obtained sufficiently pure, it would exhibit properties strikingly distinct from the common variety. We have undertaken the experiments, with the following results:

Good stick phosphorus is taken, and boiled for some time in strong solution of potassium hydrate, and water occasionally added to replace that lost by evaporation. Care must be exercised, by cautious stirring, to prevent the melted phosphorus from being carried to the surface by bubbles of disengaged gas. After boiling for five or ten minutes, the liquid phosphorus is carefully washed by replacing the alkaline solution by a stream of cold water. In this way the hypo-phosphates are removed, as well as the liquid and gaseous hydrides of phosphorus. The liquid modification thus obtained possesses the following peculiarities, which we believe entitle it to a place as one of the allotropic states of phosphorus:

1st. That of retaining for an apparently indefinite time its liquid condition, at temperatures far below the melting-point of the ordinary material. A carefully prepared specimen has been kept by us beneath a water surface for the past four months. It is still in the liquid state, at the time of making this communication and seems to promise to keep this state for an indefinite time. To make the retention of its liquidity still more striking, it may be remarked that the room in which the specimen is preserved has been for several weeks without a fire, the temperature probably reaching 40° F., a point far below the melting-point of ordinary phosphorus. The specimen in question was poured into a small test tube, and covered with about an inch of water. The test tube was then hung by a string in a place where it was secure from sudden jars or shaking. We have every reason for believing that this specimen, in common with numerous others experimented upon, will instantly solidify upon being touched.

A specimen of the liquid modification was placed beneath a water surface, and exposed to artificial cold produced by the evaporation of

ether. It solidified at about 38° F. With larger specimens and under more favorable conditions, the reduction may possibly be carried still further.

2d. Another peculiarity of the liquid modification is that of its non-oxidation when exposed to direct contact of air.

3d. As a result of this last mentioned property, the liquid does not shine in the dark. Ordinary and liquid phosphorus were exposed under the same circumstances to the air in a dark room. The common variety emitted the well known light, the other was entirely non-luminous.

There result apparently two distinct varieties of solid phosphorus from the solidification of the liquid modification. One is tough and waxy, like the ordinary material, the other is quite brittle and crystalline. We have noticed that in all cases well prepared specimens of the liquid produced on solidification the second variety, while poor or indifferent ones the first. We, therefore, regard that from which the second is produced as the true liquid modification.

The brittle crystalline solid thus produced comports itself somewhat differently from the ordinary variety. It oxidizes rapidly in the air, and raises its temperature so rapidly as to melt down into a liquid state, in which it is very easily inflammable.

In order to test whether the liquid modification underwent any change of volume at the moment of solidification, the following experiment was made: A small specimen was placed in a test tube, and covered with water. A stout glass tube, having one end drawn out into a capillary, was inserted into a cork, and tightly placed in the tube, The whole apparatus was then filled with water to within an inch of the top of the capillary. No appreciable change of volume could be detected at the moment of solidification, though it is possible that the diminution of bulk consequent on the passage from the liquid to the solid state, was exactly neutralized by the expansion produced through the heat developed by solidification.

To test whether the temperature of the boiling point had any effect in producing the liquid modification, stick phosphorus was boiled in a concentrated solution of zinc chloride. The result was a variety which with difficulty retained its liquidity, and on cooling, exhibited the waxy texture of the ordinary material. A high boiling point cannot, therefore, be the cause of the change.

Experiments were also made to ascertain whether the new modification were some compound of phosphorus with hydrogen. The result seemed to show this not to be the case. It may be mentioned incidentally, that during the conduct of some of these experiments a fact not generally known was observed. In a bulb blown in the middle of a glass tube small pieces of stick phosphorus were placed, and the ends of the tube were drawn out. One of these was placed in connection with a small hydrogen gasometer, and the phosphorus in the bulb melted by cautiously applied heat. Combination of course ensued, and there escaped from the free end of the tube a spontaneously inflammable hydride, whose tempera-

ture was so low as to render it incapable of igniting the free hydrogen issuing with it. After a few moments' heating, the tube was hermetically sealed. A liquid phosphorus was produced differing markedly from that obtained by boiling with caustic potash. It was very mobile, of a clear amber color, and on solidifying, assumed the tough, waxy state.

The physical peculiarities exhibited by the modification which we have studied seem fairly to entitle it to a place as one of the allotropic conditions of phosphorus. Indeed, they are much more strongly marked than those upon which the elastic variety of sulphur are based.

ABSTRACT OF THE REMARKS OF PROF. COPE AT THE MEETING OF THE AMERICAN PHILOSOPHICAL SOCIETY, JANUARY 16, 1874.

An analysis of the osteotology of the extinct ruminant *Poëbrotherium* (Leidy), from the Miocene of the Western territories, determines some interesting relations to the living and extinct members of the order. The cervical vertebræ indicate affinity to the *Camelidæ*, and there is nothing in the remainder of the structure to contradict such relation. The separation of the *os trapezoides* is found in the camels, and very few others only among *Ruminantia*, but in the presence of the *trapezium*, *Poëbrotherium* shows relationships to more ancient types, as *Anoplotheriidæ*, &c. The reduction of the digits to two, and the separation of the metacarpals, point in the same direction; indeed, the number of carpals and metacarpals is precisely as in *Xiphodon*. But the mutual relations of these bones are quite different from what exists in that genus, and is rather that of the *Camelidæ* and other Ruminants, or what Kowalevsky has called the "adaptive type." This author has seen in the genus *Gelocus*, Aym., from the lowest Miocene or upper Eocene the ancestor of a number of the types of the order, but among these he does not include the *Camelidæ*. The present genus is a more generalized type than *Gelocus*, in its separate trapezoid and distinct metacarpals, and represents an early stage in the developmental history of that genus. It also presents affinity to an earlier type than the *Tragulidæ*, which sometimes have the divided metacarpals, but the trapezoides and magnum co-ossified. In fact, *Poëbrotherium* as direct ancestor of the camels, indicates that the existing *Ruminantia* were derived from three lines, represented by the genera *Gelocus* for the typical forms, *Poëbrotherium* for the camels, and *Hyaemoschus* for the *Tragulidæ*. The first of these genera cannot have been derived from the second, on account of the cameloid cervical vertebræ of the latter, and all three must be traced to the source whence were derived also the *Anoplotheriidæ*, perhaps the little known *Dichodontidæ*.

The two distinct metacarpals, separate trapezium and trapezoides, cameloid cervical vertebræ, and dentition characterize this type as a peculiar family, which may be called *Poëbrotheriidæ*. The genus from which it takes its name was originally referred by Leidy to the *Camelidæ*. The genera *Hypertragulus*, Cope; *Leptomeryx*, Leidy; and *Hypisodus* Cope, are probably *Tragulidæ*.

ORIGIN OF ATTRACTIVE FORCE.

By Prof. Pliny Earle Chase.

(*Read before the American Philosophical Society, February 6th*, 1874.)

The theoretical cycles and epicycles of Ptolemy and his predecessors, the vortices of Descartes, the æther of Newton, were all suggested by an instinctive search for some simple primitive form or cause of motion.

Gravitation is supposed to act under uniform laws in all parts of the universe, and many attempts have been made to refer it to some form of æthereal undulation. Its proportionality, directly to the mass and inversely to the square of the distance, may be readily accounted for on the hypothesis that it is the resultant of infinitesimal impulses, moving with a uniform velocity.

Prof. Stephen Alexander has supposed that the Star System, of which our Sun is a member, is a spiral with several branches. The logarithmic parabola between α Centauri and the Sun, which I have pointed out as controlling the positions of the planets,* confirms this hypothesis, and also furnishes evidence of a material, elastic, slightly compressible æther.

In the spherical undulations of such an æther, propagated like the waves of light, the perimetral disturbance must be π times as great as the synchronous diametral disturbance.

Under the action of central forces, in consequence of the synchronism in all orbits of the same major axis:—

1. A body would describe a circular orbit in the same time that it would oscillate through the centre, over a space equivalent to two diameters. The velocity of the circular oscillation would therefore be $\frac{\pi}{2}$ of the mean velocity of the radial oscillation.

2. A body would oscillate from a circumference to the centre and return, in $(\frac{1}{2})^{\frac{1}{2}}$ of the time of orbital revolution.

3. A body would oscillate through a diameter and return in $(\frac{1}{2})^{\frac{1}{2}}$ of the time of orbital revolution, or in the time which would be required for revolution through the same orbit, with the velocity acquired by infinite impulsion to the circumference.

4. If the velocity of orbital approach to a focus of central force is so retarded, by collisions or otherwise, as to change the orbit from a parabola to a circle, the velocity of the circular oscillation will be $\frac{\pi}{2}$ of the mean velocity of the retarded radial oscillation.

Let us suppose that the planetary groupings, as well as the velocities of planetary revolution, solar and planetary rotation, and solar motion in space, are all resultants of successive infinitesimal impulses, moving with a uniform velocity, and propagated through the medium of a universal æther.

* Proc. A. P. S., Sept. 20, 1872.

If, in consequence of points of inertia, centripetal undulations are established, resulting in a motion of æthereal particles around the centres of inertia, and an accompanying impulsion of denser particles towards the centres, the mean velocity of the circular motion would be one-half as great as that of the originating impulse, and $\frac{\pi}{2}$ as great as the mean velocity of centripetal impulsion.

If a homogeneous rotating globe were aggregated under such centripetal impulsion, the angular orbital velocities of all the particles of the globe would be equally retarded. Rotation is, therefore, merely retarded revolution, and in endeavoring to trace them both to their source, we should compare them at the point of equality.

We know that the hypothetical universal medium is susceptible of undulations, which are propagated with the velocity of light. Therefore let—

V^{λ} = velocity of light, = 2 × hypothetical mean velocity of æthereal primary rotation, the velocity communicable by the infinitesimal impulses varying between 0 and V^{λ}.

$\frac{V^{\lambda}}{\pi} = \frac{2}{\pi} \times \frac{V^{\lambda}}{2}$ = mean velocity of a perpetual radial oscillation, synchronous with a circular orbital oscillation having a velocity $= \frac{V^{\lambda}}{2}$.

$V' = \frac{\lambda}{\pi n}$ = velocity of planetary revolution at the Sun's equator, under the volume due to internal work.

$V'' = \frac{V^{\lambda}}{\pi n^2}$ = velocity of solar equatorial rotation, under the volume due to internal work, = mean velocity of an oscillation through Jupiter's radius vector synchronous with Jupiter's revolution around the Sun; Sun and Jupiter being regarded as constituting a binary Star.

$V''' = 4V''$ = mean velocity of a perpetual radial, or infinitely eccentric oscillation, synchronous with the revolution of the binary Star around its centre of gravity (374335329 seconds) = mean velocity of the binary Star in space.

T', T'' = time of revolution, rotation, for V', V''.
t', t'' = " " " Earth.
τ', τ'' = " " " Jupiter.

$\frac{2V^{\lambda}}{T''}, \frac{2V'}{t''}, \frac{2V'}{\tau''}$ = equatorial g, at Sun, Earth, Jupiter.

$\frac{\pi^{\nu}}{3\,2}$ = ratio of the integral of infinitesimal impulses during revolution in a circular orbit, π^{ν}, to the integral of similar impulses during fall from circumference to centre of same orbit.

$\frac{\pi^6}{\gamma\gamma}$ = Neptune's mean heliocentric distance, in units of Earth's mean distance.

$\frac{\pi^5}{\gamma\gamma}$ = Saturn's mean distance.

$\frac{\pi^4}{\gamma\gamma}$ = Asteroidal mean distance, or twice the mean distance of Mars.

$\frac{\pi^3}{\gamma\gamma}$ = Earth's secular mean perihelion distance.

$\frac{\pi^2}{\gamma\gamma}$ = Mercury's " " "

$\frac{\pi^1}{\gamma\gamma}$ = Major axis of Sun's orbit about centre of gravity of binary Star.

$\frac{\pi^0}{\gamma\gamma}$ = Heliocentric distance of linear centre of oscillation of secular mean perihelion centre of gravity of the binary Star.

The ratio of V' to V'' was determined by supposing Sun's radius to vary from r to n^2r. In such case, $V' \propto \frac{1}{n}$; $V'' \propto \frac{1}{n^2}$.

In the following table, A represents the theoretical values of T'' and V'' as estimated from $V\lambda$; B, from Jupiter's distance $\left(V'' = \frac{2\pi\tau'}{\triangle}\right)$; C, the observed values. For T'', C is the mean of the six several estimates by Bianchi and Laugier, Lelambre, Petersen, Spörer, Carrington, and Faye. The Sun's annual motion is given in units of Earth's radius vector, C being Struve's estimate. For V', A, B, C, are respectively deduced from g at Sun, Earth, Jupiter.

	A	B.	C
T''.....	2203645 sec.	2163907 sec.	2162802 sec.
V'.....	265.66 mi.	261.79 mi.	261.56 mi.
$4\,V'' \times 1$ yr.....	1.678 r.v.	1.754 r.v.	1.623 r.v.

The slight discrepancies in these values seem to be attributable to the mean orbital eccentricity of the binary Star, but they are all within the limits of uncertainty of observation. The heliocentric distance of the mean perihelion centre of gravity of the binary Star, is 1.0188 × solar radius; Jupiter's mean orbital eccentricity is .04316.

The correspondence between the theoretical and observed values of the $\frac{\pi^y}{\gamma\gamma}$ series is given below, in units of Sun's radius. It is specially noticeable that the series groups the principal planets into pairs. The values of the secular mean apsides are taken from Stockwell's "Memoir on the secular variations of the orbits of the eight principal planets."

	Theoretical.	Observed.
Neptune, mean.....	6450.776	6453.731
Saturn "	2053.346	2049.514
Asteroid "	653.600	654.760
Earth, perihelion.....	208.048	207.583
Mercury, "	66.224	68.483
Sun, major axis.....	2.136	2.132
Primary centre oscillation.....	.679	.679

ON THE LATENT HEAT OF EXPANSION IN CONNECTION WITH THE LUMINOSITY OF METEORS, ETC.

By B. V. Marsh.

(*Read before the American Philosophical Society, March* 6, 1874.)

In 1863, in a paper published in Silliman's Journal (vol. xxvi. p 92), I attempted to show that the luminosity of meteors is probably due to the effects of latent heat.

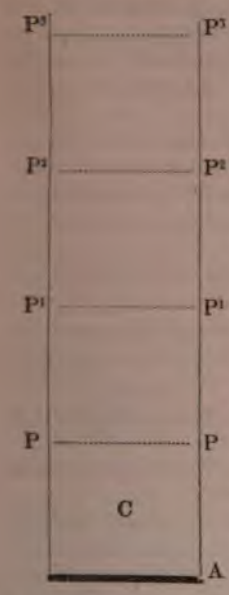
An abstract of my results was made by the "Luminous Meteor" Committee of the British Association, and published in 1864 with their report. The paper was also favorably referred to by Haidinger;* but it evidently has not been accepted as furnishing a satisfactory solution of the problem.

My explanation was based upon the assumption that when air is heated "under a constant pressure," the heat required to produce a given elevation of temperature, in excess of that required to produce the same change of temperature "under a constant volume," remains latent in the expanded air. But according to the dynamical theory of heat, the most of this excess is employed in lifting the weight of the atmosphere; a glance, however, at the tabular statement in my paper, shows that a very small fraction only of this excess is actually required to produce all the effects which I attributed to it. Hence, although "latent heat of expansion" seems to be generally ignored, I have always—in view of the remarkable correspondence of the observed phenomena with what might be expected to occur, supposing my explanation to be correct—felt an assurance that it must have some foundation in truth. The fire-balls of December 24th and January 2d having prompted me to re-examine the question, I find this impression strongly confirmed, and therefore venture again to call attention to the subject, hoping to make it appear probable, not only that "latent heat of expansion" is a reality, but that it plays a leading part in all the luminous phenomena of the upper regions of the atmosphere.

Tyndall, in his treatise on "Heat as a Mode of Motion" (New York,

* Memoire sur les relations qui existent entre les étoiles filantes, les bolides, et les essaims des météorites; par M. Haidinger, Associé de l'Académie—Bulletins de l'Academie Royale de Bruxelles, 2e series, T. XVII., 1864, p. 133 "M. Quetelet, dans son important ouvrage sur la *Physique du Globe*, publié en 1861 (p. 5), désigne ces couches par les noms *d'atmosphere mobile* ou *dynamique*, et *d'atmosphere immobile* ou *stable*. Les considerations publiées par M. Benjamin V. Marsh dans le journal americain du Professeur Silliman ont grande importance relativement à l'existance de deux couches atmosphériques de nature différente."

1863, p. 83), says: "Let C be a cylindrical vessel, with a base one square foot in area. Let P P mark the upper surface of a cubic foot of air at a temperature of 32° F. The height A P will then be a foot. Let the air be heated till the volume is doubled. To effect this it must, as before explained, be raised 490° F. in temperature, and, when expanded, its upper surface will stand at P^1 P^1, one foot above its initial position. But in rising from P P to P^1 P^1, it has forced back the atmosphere, which exerts a pressure of 15 lbs. on every square inch of its upper surface; in other words, it has lifted a weight of $144 \times 15 = 2{,}160$ lbs. to a height of one foot.



The capacity for heat of the air thus expanding is 0.24; water being unity. The weight of our cubic foot of air is 1.29 oz., hence the quantity of heat required to raise 1.29 oz. of air 490° F. would raise a little less than one fourth of that weight of water 490°. The exact quantity of water equivalent to our 1·29 oz. of air is $1.29 \times 0.24 = 0.31$ oz. But 0.31 oz. of water heated to 490° is equal to 152 oz., or 9½ lbs heated 1°. Thus the heat imparted to our cubic foot of air, in order to double its volume and enable it to lift a weight of 2,160 lbs. one foot high, would be competent to raise 9½ lbs. of water one degree in temperature.

The air has been heated *under a constant pressure*, and we have learned that the quantity of heat necessary to raise the temperature of a gas under constant pressure a certain number of degrees, is to that required to raise the gas to the same temperature *when its volume is kept constant*, in proportion of 1.42 : 1; hence we have the statement 1.42 : 1=9.5 lbs. : 6.7 lbs., which shows that the quantity of heat necessary to augment the temperature of one cubic foot of air, at a constant volume, 490°, would heat 6.7 lbs. of water one degree.

Deducting 6.7 lbs. from 9.5 lbs., we find that the excess of heat imparted to the air, in the case when it is permitted to expand, is competent to raise 2.8 lbs. of water one degree in temperature.

As explained already, this excess is employed to lift the weight of 2,160 lbs. one foot high. Dividing 2,160 lbs. by 2.8, we find that a quantity of heat sufficient to raise one pound of water one degree F. in temperature, is competent to raise a weight of 771.4 lbs. a foot high.

This method of calculating the mechanical equivalent of heat was followed by Dr. Mayer, a physician of Heilbron, Germany, in the spring of 1842."

Now, since equal additions of heat make equal additions of volume, this

process of heating and expanding might be continued indefinitely, with like results. That is to say, P^1, P^2, P^3, &c., being at intervals of one foot, the upper surface of the air will stand at P^2 when the temperature has risen twice 490°; at P^3 when it has risen three times 490° F., and so on; one volume being added for each rise of 490° in temperature, and the expenditure of heat being the same for each.

If we take for our unit, the heat required to raise the temperature of one volume of air 1° under constant volume, the total expenditure of heat whilst one volume is added to the bulk, will be $490° \times 1.4 = 686°$; and the heat expended, in excess of that required to produce the elevation of temperature alone, will be $686° - 490° = 196°$.

This expenditure has enabled the air to accomplish two results; to lift 2160 lbs. one foot high, and to fill an additional volume. Prof. Tyndall assumes that the space-filling was accomplished without the expenditure of any force whatever, and that the whole 196° were employed in lifting the weight. But, inasmuch as this may be considered an open question, we will take x to represent the heat, if any, employed in producing and maintaining the change of bulk; that is to say, the "latent heat of expansion;" and proceed to consider what must be the relation of latent heat to volume, independently of any particular value of x.

Since both the expenditure of heat, and the weight lifted, are precisely the same, during the addition of each volume, the remainder,—represented by x—must also be the same. Hence, when one volume has expanded so as to fill

2 vols.—these contain	x	degrees of latent heat, the No. in each being						$\frac{1}{2}x$
3 "	"	2x	"	"	"	"		$\frac{2}{3}x$
4 "	"	3x	"	"	"	"		$\frac{3}{4}x$
100 "	"	99x	"	"	"	"		$\frac{99}{100}x$

and so on.

Whence it appears that the less the density of the air, the greater will be the amount of latent heat, in a given volume; although, for air of considerable rarity, the change is so slight that the latent heat per volume may be considered as sensibly constant. We have treated only of the heat rendered latent during the expansion of air of standard density, which must already contain latent heat. If, however, we start from the liquid condition of air, a similar train of reasoning leads to the conclusion, that the total amount of latent heat per volume is absolutely the same for air of all densities. It must also be the same for all temperatures. For if, when the surface of the air is at P^1 we suppose the top of the vessel to be prevented from moving, and the whole to be cooled down until the temperature of the air returns to 32°—the specific heat under constant volume being the same for all temperatures—the heat given out during each degree of cooling will be the same; being exactly equal to that which, under constant volume, would be required to raise the temperature one degree. Consequently, the latent heat must remain un-

changed during the process. In other words, the latent heat is independent of temperature, and is therefore the same per volume for air of any given density, whatever may be its temperature or previous history.

Hence, as this heat represents the force which is employed in maintaining the volume of the air, and as its amount depends upon the volume alone, it may perhaps more properly be termed the "latent heat of volume"—or briefly, the "*volume heat*" of air.

It is evident that we may readily determine, in terms of x, the amount of latent heat (in excess of that rendered latent between the liquid condition and the standard pressure) contained in a given volume, or in a given weight, of the atmosphere at any height. The known law of variation of density is such that at the height of 3.43 miles the density is half that at the level of the sea—at twice that height, $\frac{1}{4}$—at three times, $\frac{1}{8}$, and so on—the density diminishing in a geometric, as the height increases in an arithmetic ratio. Whence we see that one volume at sea-level, at the height of

3.43 miles becomes	2 vols.—	containing x deg. of latent heat the No.	in each vol. being		$\frac{1}{2}$x
6.86	" 4 "	" 3x "	"	"	$\frac{3}{4}$x
10.29	" 8 "	" 7x "	"	"	$\frac{7}{8}$x
34.30	" 1024 "	" 1023x "	"	"	$\frac{1023}{1024}$x
68.60	" 1,048,576	" 1,048,575x	"		$\frac{1,048,575}{1,048,576}$x

and so on.

The volume, and consequently the latent heat, of a given weight of air being doubled by each addition of 3.43 miles to the height, it is evident that each molecule of air, near the upper limits of the atmosphere, has, associated with it, an enormous amount of latent heat. But this need not excite great surprise: for when we consider that $\frac{1}{3}$ of a grain of air at the surface of the earth occupies only one cubic inch, whilst at the height of one hundred miles the same occupies one thousand millions of cubic inches, every part filled completely and equably, each molecule being held in its place at a certain definite distance from its fellows, we cannot doubt that it has abundant use for all its stores of energy, in constructing and maintaining the framework of this vast edifice; unless, indeed, we conclude that space-filling is a kind of work which—unlike every other—does itself.

We may form some idea of the value of x, by comparing the heat expended with the work done, in the experiment already quoted from Tyndall. He shows that the expediture of heat, in excess of that required to raise the temperature under constant volume, is competent to raise 1° the temperature of 2.8 lbs. of water. If we take 772 foot-pounds as the mechanical equivalent, the same would be competent to raise $2.8 \times 772 = 2161.6$ lbs. one foot high, showing an excess of 1.6 lbs. over the weight actually lifted. The amount of heat applicable to the work of expansion or space-filling, for this value of the equivalent, is therefore very

small. But there is some evidence in favor of a larger value of Joule's equivalent, and, consequently, in favor of a larger value of x.

In his final paper,* Joule announces the following results from his experiments:

From 1st Series, consisting of 40 experiments from friction of water, value of equivalent. 772.692

"	2	"	"	20	" mercury	"	772,814
"	3	"	"	30	" "	"	775.352
"	4	"	"	10	" cast-iron	"	776.045
"	5	"	"	10	" "	"	773.930

Whence we see that the mean result from the whole 110 experiments was..... 773.857

Joule adds, "I consider that 772.692, the equivalent derived from the friction of water, is the most correct, both on account of the number of experiments tried, and the great capacity of the apparatus for heat; and since, even in the friction of fluids, it was impossible entirely to avoid vibration, and the production of a slight sound, it is probable that the above number is slightly in excess;" and he concludes by adopting 772 as the most probable value.

Now, inasmuch as, in the case of cast-iron, he had made an experimental determination of the heat expended in the production of sound, and had allowed for it; and since no further explanation is given, we must look upon his final conclusion as based upon the 40 experiments with water alone; the fractional part being rejected in consideration of probable loss from the noise produced in that series of experiments.

Although Joule thus ignored nearly two-thirds of a series of experiments, all of which had been conducted with equal care, and each of which would therefore seem to be entitled to some weight, he placed their results upon record; and we may certainly be permitted to inquire what consequences would have followed the adoption of the purely experimental value which the whole series indicated—773.857.

Adopting this as the mechanical equivalent of heat, we find the force competent to lift $2.8 \times 773.857 = 2166.8$ lbs. one foot. But the weight actually lifted was 2160.0 lbs. one foot. Hence, a force competent to lift 6.8 lbs. one foot has become latent, having been employed in producing and maintaining the expansion; but, inasmuch as the quantity of heat necessary to augment the temperature of one cubic foot of air (weighing 1.29 oz.) at a constant volume, 490°, would heat 6.7 lbs. of water 1°, it would be competent to lift $6.7 \times 773.857 = 5184.8$ lbs. one foot high; whence we have the statement:

Foot-pounds. Foot-pounds.

as 5184.8 : 6.8 : : 490° : 0.642° = x, showing that sufficient heat was rendered latent, to raise the temperature of the whole mass of air (1.29 oz.) at a constant volume, 0.642 degrees.

* Philosophical Transactions 1850.

Owing to the uncertainty as to the exact ratio of the two specific heats of air, and as to the exact value of the mechanical equivalent of heat, an accurate determination of the value of x cannot yet be reached; but since the above value is based upon the complete series of experiments made by Joule in 1849, it must be entitled to consideration as a first approximation, and may be used to illustrate the action of latent heat in the production of luminous phenomena.

But we are here met by the assertion of several standard writers, that the existence of latent heat of expansion was positively disproved by a certain experiment performed by Joule, who announced in the Philosophical Magazine for May, 1845, that "no change of temperature occurs when air is allowed to expand in such a manner as not to develop mechanical power."

Although the interpretation thus put upon Joule's words seems to be perfectly natural and legitimate, an examination of the memoir in which he describes his experiments, and announces this conclusion, seems to show that he did not intend them to be so interpreted.

Prof. Balfour Stewart, in his "Treatise on Heat" (1871, p. 317) says: "Many familiar experiments show that when a gas is suddenly compressed, there is a production of heat, and that when suddenly expanded there is an absorption of heat.

Séguin and Mayer had already suggested the use of gases and vapors for the purpose of determining the mechanical equivalent of heat; and air, the substance chosen by Mayer, was no doubt very good for such a purpose; nevertheless, the suggestions of these philosophers do not seem to have been accompanied with a clear appreciation of all the data necessary to a complete proof.

Joule, however, in his experiments, supplied what was wanting in order to derive a good determination of the mechanical equivalent of heat from the known gaseous laws. By compressing air forcibly into a receiver surrounded by water he found that the water was considerably heated. It is not, however, correct to infer without further experiment that the amount of heat produced in this case is the exact equivalent of the energy expended in compressing the air. A familiar instance will make this clear. By a blow of a hammer upon a small quantity of fulminating mercury, it is exploded, and produces a considerable amount of heated gas, but we are not at liberty to suppose that all the heat thus developed is merely the mechanical equivalent of the energy of the blow, as will be evident by supposing such an extreme case as a ton of fulminating powder.

Evidently the substance is in a different molecular condition at the end of the experiment and at the beginning, and it may be supposed with much truth that the heat produced is nearly all due to the conversion into a kinetic form of a certain potential energy present in the compound. Now in the experiment above described, in which air is compressed, the air is evidently in a different molecular condition after compression, for

the particles are much nearer together. The first thing, therefore, is to determine how much, if any, of the heat produced may be due to this change of the molecular condition of the air, and how much to the work expended in compressing the air.

The following very ingenious experiment performed by Joule is conclusive in showing that the mere change of distance of the molecules of a permanent gas neither produces nor absorbs heat to an appreciable extent. In the figure, we have two strong vessels, of which A contains compressed air, say under the pressure of 20 atmospheres; B, on the other hand, is a vacuum. The two vessels are connected with each other by a tube having a stop-cock, which we may suppose to be shut. The whole apparatus is plunged into a vessel of water. After the temperature of the water has been very accurately ascertained, open the stop-cock, and thus allow both vessels to have the same pressure.

When the experiment is finished it will be found that there is no change in the temperature of the water. The prevalent idea is that when air expands it becomes colder, and that when condensed it becomes hotter; but Joule, by this experiment, has shown that no appreciable change of temperature occurs when air is allowed to expand in such a manner as not to develop mechanical power."

Prof. Tyndall ("Heat considered as a Mode of Motion"—1863, p. 88,) in introducing this experiment, says: "Is it not possible to allow a gas to expand, without performing work? This question is answered by the following important experiment, which was first made by Gay-Lussac," and, after describing it, he says "We are taught by this experiment that mere rarefaction is not of itself sufficient to produce a lowering of the mean temperature of a mass of air. It was, and is still, a current notion, that the mere expansion of a gas produced refrigeration, no matter how

that expansion was effected. The coldness of the higher atmospheric regions was accounted for by reference to the expansion of the air. It was thought that what we have called the "capacity for heat" was greater in the case of rarefied than of unrarefied gas. But the refrigeration which accompanies expansion is, in reality, due to the consumption of heat in the performance of work by the expanding gas. Where no work is performed there is no absolute refrigeration."

A sufficient answer to both these would seem to be found in the fact that the "vacuum" spoken of is stated by Joule to have been obtained by means of an *air pump;* whence it appears that both vessels were *filled* with air; that in the exhausted receiver having already, during the process of exhaustion, absorbed and rendered latent, all the heat necessary for its expansion; and since we have already seen that the amount of latent heat in a given volume of air is almost entirely independent of density, we have no reason to look for any loss or gain of latent heat by the operation. The mixing of the two is quite as much a process of condensation as of rarefaction; in one receiver the air in expanding absorbs heat, whilst in the other the air being compressed gives out the heat which it had absorbed during the process of exhaustion—the two effects counterbalancing each other. The air, as a whole, just filled the two receivers at the beginning of the experiment, and it filled the same at the end; so that the effects of expansion and of condensation were completely eliminated: even more so than those of mechanical power, which Joule had especially in view when contriving this experiment.

Whilst the above seems to show that this experiment proved nothing as to the existence or non-existence of latent heat of expansion, any one who will read Joule's paper will probably be convinced that he never intended to claim that it did. He makes no allusion to any such question; and the limit which he gives of the sensitiveness of his thermometer shows that an amount of heat seventy-five times as great as that which could be expected to be rendered latent by doubling the volume of only two quarts of air, of any density, would be required to produce any appreciable change in the temperature of the 16½ lbs. of water through which, he tells us, it was distributed. He was dealing with mechanical power, and took care to have it in quantities large enough to be traced; his aim seeming to be, to solve the general question of their convertibility into heat, rather than to determine whether the results might, or might not, have been modified in some degree, by latent heat or other disturbing cause.

These considerations seem to justify us in concluding that the question of the existence of "latent heat of expansion" has not been experimentally decided in the negative, and that we may therefore proceed to inquire into its applicability to the explanation of meteoric phenomena,*

* When this paper was read, I was not aware of the language of Joule himself on this subject. Part II. of the article "On the Thermal Effects of Fluids in Motion," by J. P. Joule and Prof. W. Thomson, (Transactions of the Royal Society, 1854, vol. 144 p. 337) speaking of the "Relations between the Heat evolved and the Work spent in Compressing

using the above value of x. But, the luminosity of meteors is usually attributed to atmospheric resistance. Kirkwood, in his Meteoric Astronomy (Philadelphia, 1867, p. 81), says: "Several hundred detonating meteors have been observed, and their average height at the instant of their first appearance has been found to exceed 90 miles. The great meteor of February 3d, 1856, seen at Brussels, Geneva, Paris, and elsewhere, was 150 miles high when first seen, and a few apparently well authenticated instances are known of a still greater elevation. We conclude, therefore, from the evidence afforded by meteoric phenomena, that the height of the atmosphere is certainly not *less* than 200 miles.

It might be supposed, however, that the resistance of the air at such altitudes would not develop a sufficient amount of heat to give meteorites their brilliant appearance. This question has been discussed by Joule, Thomson, Haidinger, and Reichenbach, and may now be regarded as definitively settled. When the velocity of a meteorite is known, the quantity of heat produced by its motion through air of a given density is readily determined. The temperature acquired is the equivalent of the force with which the atmospheric molecules are met by the moving body. This is about one degree F. for a velocity of 100 feet per second, and it varies directly as the square of the velocity. A velocity, therefore, of 30 miles in a second would produce a temperature of 2,500,000°. The weight of 5,280 cubic feet of air at the earth's surface is about 2,830,000 grains. This, consequently, is the weight of a column one mile in length, and whose base or cross section is one square foot. The weight of a column of the same dimensions at a height of 140 miles would be about

a Gas kept at a constant temperature," says, "This relation is not a relation of simple mechanical equivalence, as was supposed by Mayer. * * * The first attempt to determine the relation in question for the case of air established an approximate equivalence without deciding how close it might be, or the direction of the discrepancy, if any. Thus experiments "On the Changes of temperature produced by the Rarefaction and Condensation of Air," (Philosophical Magazine, May, 1845) showed an approximate agreement between the heat evolved by compressing air into a strong copper vessel under water, and the heat generated by an equal expenditure of work in stirring a liquid; and again conversely an approximate compensation of the cold of expansion when air in expanding spent all its work in stirring its own mass, by rushing through the narrow passage of a slightly opened stop-cock."

Whilst this language fully confirms my interpretation of Joule's experiment, the inference drawn by the authors from their subsequent experiments upon air forced through a "porous plug," composed of compressed cotton-wool or silk, is incompatible with the theory which I have advanced. They showed that when air was forced through such a plug, its temperature was lowered; and that the cooling effect was in proportion to the difference in the pressure of the air, on the two sides of the plug. For reasons previously stated by Prof. Thomson, (Transactions of the Royal Society of Edinburgh, vol. xx., 1851) they assumed that this cooling effect represented the amount of heat rendered latent by expansion; and hence concluded that this, also, varied directly as the difference of pressure.

It is, however, by no means self-evident, that the mechanical energy of the condensed air would be exactly balanced—neither more nor less—by the work done in overcoming the friction of the plug, and thus completely isolate the effects of latent heat of expansion This being only a theoretical deduction, ought not to have the weight of a direct result from experiment. Hence, perhaps, the omission of Tyndall and of Stewart to allude to it. If standard writers thus fail to recognize it as conclusive, we may fairly consider the subject as still open to discussion.

$\frac{1}{130000}$th of a grain. Hence, the heat acquired by a meteoric mass whose cross section is one square foot, in moving one mile, would be one grain raised $7\frac{1}{7}$ degrees, or one-fifth of a grain 2,500° in 70 miles. This temperature would undoubtedly be sufficient to render meteoric bodies brilliantly luminous."

The above is a very clear statement of the resistance theory, which is the only one which seems to have met with general acceptance. But when we consider that the heat resulting from the collision of the atmospheric molecules with the surface of the meteorite, being developed at that surface, must be to a great extent absorbed by the meteorite ; and that, in the case supposed above, a body more than one foot in diameter had to travel seventy miles, to develop heat competent to raise one-fifth of a grain to a temperature less than that of melting iron, we must conclude that, at the height of 140 miles, the resistance theory utterly fails to account for any luminosity whatever.

In order to give some definite form to the discussion of the comparative effects of resistance and of latent heat in the production of meteoric luminosity, let us, with Kirkwood, suppose a globular meteor of one square foot section to enter the atmosphere with a velocity of thirty miles per second.

In traveling one mile, it will sweep a cylindrical space one mile long containing 5280 cubic feet, all the air in which will be compressed to a density at least as great as that of air at the surface of the earth, and be carried forward in front of the meteor. When in approaching the earth denser strata are reached, some portion of the air will of course be merely pushed aside and left behind, the air piled up in a conical mass in front of the meteor, dividing the atmosphere, just as the sharp bow of a vessel divides the water and thus diminishes the resistance ; but at great heights, if the velocity be great, this effect may be neglected.

Heat will be developed at the forward surface of the meteor, *firstly*—from the *resistance* of the air, which converts into heat a portion of the kinetic energy or motive power of the meteor ; its amount, at any given velocity, depending upon the *weight* of the air met ; *secondly*—from the release of *latent heat*, the amount of which depends only on the *bulk* of the air met.

The mere mention of the fact that the heating power of "resistance" depends upon the weight ; and that of "latent heat" upon the bulk of the air encountered, shows the great advantage which the latter has at extreme heights. "Latent heat" is at its maximum at the extreme upper limit of the atmosphere, where there is no appreciable weight of air to absorb the heat developed at the surface of the meteor. Its whole energies are therefore expended on the meteor, the surface layer of which may be so heated as to cause it to burst out in full splendor very soon after entering the atmosphere, and at a height where the weight of air encountered is so infinitesimally small that the effects of "resistance" are not perceptible : but no luminosity can be expected from either source until the heat developed is sufficient to produce incandescence, both in the surface layer of the meteor, and in its atmospheric envelope.

The comparative, as well as the absolute effects of "resistance" and of "latent heat" are illustrated in the accompanying tabular statement; from which we see that at the height of 103 miles, the latent heat is sufficient to raise the temperature of all the air met, six hundred millions of degrees; at sixty-eight miles, six hundred thousand degrees; at fifty-one miles, twenty thousand degrees; at thirty-four miles, six hundred

HEIGHT IN MILES.	WEIGHT IN GRAINS of air met in 1 mile by meteor 1 square foot cross section.	HEATING POWER OF LATENT HEAT in 1 grain of air at different heights.	HEATING POWER OF LATENT HEAT of air met in 1 mile at any considerable velocity.	HEATING POWER OF RESISTANCE of air met in 1 mile at a velocity of 30 miles per second.
nm.	$\frac{w}{2^n}$	$(2^n-1)x$	$\frac{2^n-1}{2^n}wx$	$M\frac{v^2}{64\frac{1}{2}\times772\times0.24}$
3.43	1491500	$\frac{2}{3}$	957543	3138839377500
17.15	93219	20	1855240	196175882730
34.30	2913	657	1913216	6128260320
51.45	91	21250	1915028	191508134
68.60	3	673200	1915084	6313454
85.75	$\frac{3}{32}$	21474800	1915086	197296
102.90	$\frac{3}{1024}$	687195000	1915086	6166
120.05	$\frac{3}{32768}$	21990233000	1915086	192
137.20	$\frac{3}{1048576}$	703687442000	1915086	6
154.35	$\frac{3}{33554432}$	22517998137000	1915086	$\frac{2}{16}$
171.50	$\frac{3}{1073741824}$	720575940380000	1915086	$\frac{2}{512}$
188.65	$\frac{3}{34359738368}$	23058558092137000	1915086	$\frac{2}{16384}$
205.80	$\frac{3}{1099511627776}$	737873858948446000	1915086	$\frac{3}{524288}$

Explanation:—M = mass of air. v = velocity of meteor in feet.
m = 3.43. nm = height in miles.
w = number of grains of air in 5,280 cubic feet at level of the sea = 2,983,000.
x = heat rendered latent by each addition of 1 vol. = 0.642° Fahr.

degrees (about the temperature of melting lead); whilst at the height of seventeen miles, the whole of the latent heat would be required to raise the temperature of the air only twenty degrees. From this it is evident that "latent heat" fails entirely as a source of luminosity at all heights below forty miles. On the other hand, whilst at great heights the effect of "resistance" is insignificant and altogether inadequate to the production of any splendor, its power at the height of forty, or even of fifty miles, seems almost unlimited. "Latent heat" and "resistance" together cover the whole field. Luminosity from "resistance" would commence at a height of eighty-five miles, more or less, according to velocity, and would increase rapidly with *decrease* of height, so that at the height of thirty-four miles it would be more than thirty thousand times as great as at eighty-five miles; whilst "latent heat" would cause the meteor to burst out in full splendor as soon as it had penetrated the atmosphere far enough to develop an amount of heat competent to vaporize its outer layer: and to disappear entirely, at a height of more than forty miles.

It is a significant fact, that very few meteors have been known to retain their luminosity below that point. Indeed, whilst some of the observed phenomena are such that "resistance" alone cannot afford any explanation whatever, they are all in perfect accord with the requirements of the "latent heat" theory. Hence we seem to be justified in concluding that "latent heat" is the *principal* source of meteoric luminosity.

The second column in the table gives the heating power of a unit of weight of air at different heights: showing, that one grain at the height of three and a-half miles, if compressed until its density equals that of air at the sea-level, will give out only enough heat to raise the temperature of one grain of air under constant volume about two-thirds of one degree; but that at the height of eighty-five miles the heat given out will suffice to raise the temperature of one grain twenty millions of degrees; at one hundred and thirty-seven miles, seven hundred thousand millions of degrees; whilst at the height of two hundred and five miles the number would exceed seven hundred thousand millions of millions.

This implies a condition of things somewhat similar to that suggested by Mr. Birks in his chapter on the "*Igneous condition of matter*,"* when he says, "There will thus, according to the present theory of the laws of matter, be more truth than has latterly been recognized, in the old arrangement of the four elements, which placed a fourth region of fire, above the solid, liquid, and gaseous constituents of our globe. In fact above the region where the air, though greatly rarefied, is still elastic, there must be a still higher stratum where elasticity has wholly ceased, and where the particles of matter, being very widely separated, condense around them the largest amount of ether. All sensible heat, in the

* On Matter and Ether or the Secret Laws of Physical Change, by Thomas Rawson Birks, M. A., Cambridge, (England) 1862.

collision or oscillation of neighboring atoms of matter, will thus have disappeared: but latent heat, in the quantity of condensed ether or repulsive force, ready to be developed on the renewed approach of the atoms, will have reached its maximum, and may be capable of producing the most splendid igneous phenomena, like the northern lights or tropical thunder storms."

Quetelet, in view of the phenomena peculiar to the upper air, proposed to consider it as a distinct atmosphere, and says* "This upper atmosphere, favorable to the combustion and brilliance of shooting stars, would not necessarily be of the same nature and the same composition, as the lower atmosphere in which we live."

Sir John Herschel also seems to recognize something not unlike what I have suggested, when, in writing to Quetelet of shooting stars, in August, 1863, he says,† "As to their great elevation above the earth, it leads us to *suspect* the existence of a kind of atmosphere higher up than the aërial atmosphere, lighter, and, so to speak, more *igneous* than our own."

The train of reasoning which I have suggested leads to the conclusion that this "more igneous" condition commences at a height of forty or fifty miles, and extends to the utmost limit of the atmosphere; its intensity increasing with the height in a geometric ratio—the outer shell of air being so completely saturated with heat, that, like a sponge filled with water, it responds to the slightest pressure. It is evident that this fiery envelope may prove a most efficient shield to protect us from the effects of collision with all sorts of fragmentary missiles which the earth may encounter in its journeys around the sun; and the proof of its efficiency is found in the fact that of the immense number of meteors visible, only a very few have been known to reach the earth.

Fortunately, the enormous velocity—vastly exceeding that of the swiftest cannon ball—with which these missiles are hurled at us, usually causes their almost instantaneous destruction.

Were they simply dropped from $\frac{1}{2}$ or $\frac{1}{4}$ of the height, falling with the velocity due to the earth's attraction only, it is probable that every one of any appreciable weight, would reach the earth. Without this protecting envelope, we might well dread the effects of such a bombardment as was witnessed in Italy on the 27th November, 1873, when we encountered some of the dèbris of Biela's Comet, and when the number of meteors seen by the Italian Astronomers in the course of a few hours was estimated by them at near forty thousand.

The fact seems to be, that the planetary velocity with which a meteor enters our atmosphere, soon causes it to develop, by compressing the air before it—heat sufficient to vaporize its surface layer, and, to communicate to it the most dazzling brightness. Time not being allowed for the

*Meteors, Aerolites, Storms and Atmospheric Phenomena. From the French of Zürcher and Margolle, by Wm. Lackland. New York, 1870, p. 229.

†Bulletins of the Royal Academy of Brussels, vol. XVI., p. 320.

heat to distribute itself through the body of the meteor, the whole of its effect is confined to the surface; extremely thin layers of which are, in succession, heated, rendered intensely incandescent, and vaporized, however refractory the material.

The black "crust," of the thickness of letter paper, with which the stony meteorites are coated, shows the limits for any one instant, of the melting process; and the fact, that beneath the crust there is no trace of the action of fire, is proof, both of the extreme intensity of the heat, and of its entirely superficial distribution.

Another disintegrating process may, perhaps, be mainly confined to the smaller meteorites and to the ordinary shooting stars, which are so completely dissipated that no trace of them reaches the earth. Although, in any individual layer, the three states—solid, liquid, and vapor—exist almost at the same instant, they must in reality succeed each other in the order named; so that there must always be a layer in which the material, although not melted, is so intensely heated as to exert an expansive energy tending to split the mass into fragments. The amount of decrepitation thus produced must, of course, depend upon the brittleness and other peculiarities of the meteor, as well as upon its velocity and upon the density of the air encountered; but the effect must be similar in character to that which takes place when coal being thrown upon the fire of a locomotive, minute fragments split off by the sudden expansion, are carried up the chimney and fall upon the car-roof in such numbers as to remind passengers of the rattle of a shower of hail.

It can scarcely be supposed that combustion has much to do with the splendor of meteors, or with their destruction, since these mainly occur at heights at which there is not air enough to maintain combustion to any considerable extent. Their disintegration must therefore be mainly effected by heat alone, unaided by chemical action.

Frequently, after the disappearance of a meteor of extraordinary splendor, a luminous train or cloud remains for a few seconds, sometimes for several minutes, and in some very rare instances they have remained visible for an hour or more. A remarkable example of this occurred on the 14th of November, 1868, when, shortly after midnight, a meteor appearing over Northeastern Pennsylvania, left a cloud which remained visible to observers at Washington and New Haven and at all intermediate points, for about three-quarters of an hour. According to Prof. Newton,* the observations indicated for this cloud "a real diameter of one mile, and a volume of a dozen or a score of cubic miles," and that whilst visible it moved about forty miles, showing an average velocity relatively to the earth of nearly a mile per minute. What was its velocity relatively to the air is not known. This cloud was, no doubt, the débris of the meteor, a cloud of meteoric dust, moving rapidly through the air, compressing the air before it; and, of course, if the above views be correct, developing heat and light, just as, on a grander scale, heat and light

* Silliman's Journal, vol. 47, p. 406.

had before been developed by the motion of the meteor itself. The intensity of the light must of course, diminish with the loss of relative velocity, and altogether cease whenever the cloud and the air are relatively at rest, or nearly so.*

The motion of a meteoric cloud, relatively to the air, may result either from its own momentum, from atmospheric currents, or from the diurnal rotation of the atmosphere, in which the meteor, of course, had not participated; or from any or all of these causes combined, so that it must in almost all instances be very considerable.

The light of the aurora may perhaps in like manner be due to latent heat; for although rarefied air is a very good conductor, it probably offers resistance to the passage of electric currents sufficient to produce a momentary condensation quite competent to illuminate their paths.

It is evident that if the upper air be in the condition suggested, the track of *every* mechanical impulse, traversing it with considerable velocity, must become luminous.

This igneous condition of rarefied air necessarily implies a definite limit to the atmosphere of each member of the solar system: otherwise, meteors —being constantly subjected to the action of latent heat—would be luminous, not merely when within one or two hundred miles of the earth, but at all distances.

The depth of highly rarefied air which a meteor can traverse before becoming luminous, must of course, depend upon its velocity, temperature, and conducting power; but the height at which their luminosity is seen to commence must afford some clue to the determination of the height to which the atmosphere extends.

The great comet of 1843, when in perihelion, Feb. 27, passed within sixty thousand miles of the surface of the sun, at a velocity of about 350 miles per second, and the next day was seen "as a brilliant body within less than two degrees of the sun."†

It was not seen again until about seven o'clock on the evening of March 7, when although the tail was a very conspicuous object, the brilliancy of the nucleus did not exceed that of a star of the third magnitude.

This change, so much greater than could reasonably be expected to result from increased distance from the sun, occasioned great surprise, and has not been satisfactorily accounted for.

Is it not possible that its splendor was temporarily increased by the latent heat developed during its passage through the solar atmosphere?

The great day-light meteor of Nov. 15, 1850, was seen at 9 o'clock in the morning, in full sunshine, by persons who were not within two hundred and fifty miles of any portion of its path, appearing so very bright that they thought it close at hand. Comparing the probable size

*Prof. Newton remarks (Silliman's Journal, vol. 47, p. 407,) "What kind of matter it is which remains visible in the cold upper air for three-fourths of an hour until, by gradual dissipation, the light fades out, I leave for others to say."

†Kirkwood's Comets and Meteors, Phila., 1873, p. 17.

of the comet with that of the meteor, and remembering the prodigious velocity of the former, may we not well imagine that its collision with the highly attenuated upper atmosphere of the sun might develop latent heat sufficient to enable it to rival the sun itself in splendor?

Although much of the evidence presented in favor of the existence of "latent heat of expansion," and of its agency in the production of luminous phenomena, may be said to be circumstantial only,—I trust that it will be found sufficiently cumulative, and accordant throughout, to entitle it to examination.

PHILADELPHIA, MARCH 25TH, 1874.

ON THE PLAGOPTERINÆ AND THE ICHTHYOLOGY OF UTAH.

BY EDWARD D. COPE, A.M.

Read before the American Philosophical Society, March 20th, 1874.

The observations recorded below are based on the collections made by the naturalists attached to the United States Geological and Topographical Survey west of the 100th meridian, under direction of Lieutenant Geo. M. Wheeler, and are published by permission of that officer. To Dr. Henry C. Yarrow, in charge of the department of zoology, and to A. W. Henshaw, assistant, the survey is indebted for material more fully illustrating the character and distribution of the cold blooded vertebrata of the valleys of the Colorado River and of Utah than any heretofore brought together. As one of the results derived from a study of it, it appears that the basin of the Colorado River is the habitat of a small group of fishes of the family Cyprinidæ, which may be called the *Plagopterinæ*, which embraces three genera—*Plagopterus*, Cope; *Lepidomeda*, Cope; and *Meda*, Girard. The group differs from others of the family in the possession of two strong osseous rays of the dorsal fin, the posterior of which is let into a groove in the hinder face of the anterior without being coössified with it, thus constituting a compound defensive spine. The rays of the ventral fin, excepting the first and second, are similarly modified. The greater part of their length consists of an osseous dagger-shaped spine, with grooved posterior edge, which overlaps the border of the succeeding ray, when the fin, like a fan, is closed up. The articulated portion of the ray either emerges from the groove below the free acute apex of the spine, or appears as a continuation of the apex itself. It is worth observing that the only other instance of this ossification of the ventral rays is to be seen in the extinct family of the *Saurodontidæ* of the cretaceous period, the nearest approach among recent fishes being the internal spine in the ventral fin of *Amphacanthus*. The dentition and intestine of these fishes show them to be of carnivorous habits. Interest

attaches to the *Plagopterinæ* as the only type of fishes not known from other waters than those of the Colorado basin.

PLAGOPTERUS, gen. nov.

Pharyngeal teeth, 2.5—4.2, raptorial uncinate, without masticatory surface. A terminal maxillary barbel. Scales, none; lateral line well developed. Dorsal fin with a strong spine composed of two, the posterior received into a longitudinal groove of the anterior. Ventral fins originating (in the type species) a little anterior to the line of the dorsal, attached to the abdomen by a wide basis and length of inner radius. Superior labial fold continued round the end of the muzzle.

This genus resembles *Meda*, Girard, in the presence of the dorsal spine, the adhesion of the inner border of the ventral fin, and the absence of scales, and differs in the presence of barbels, and the inner dental series being 5—4 instead of 4—4. Physiognomy of *Rhinichthys*.

PLAGOPTERUS ARGENTISSIMUS, sp. nov.

This is a small fish of slender proportions, with a rather broad head, with slightly depressed muzzle overhanging by a little a horizontal mouth of moderate size. The caudal peduncle is of medium depth, and the caudal fin is deeply forked. The eye is somewhat oval, and enters the length of the side of the head 4.2 times, and the interorbital width 1.5 times. The greatest depth (near the ventral fin) enters the total length nearly six times, or five and three quarters, exclusive of the caudal fin. The latter measurement is four times the length of the head. The origin of the dorsal is entirely behind the proper basis of the ventral; its first spine is curved and longer than the second, and its basis is intermediate between the base of the caudal and the end of the muzzle. The dorsal rays behind the spine have the basal two-thirds to one-half thickened and completely ossified, the articulated portions issuing from the apices of the spines. Radial formula, D. II. 7; C. 19; A. I 10—9; V. 2. V; P. 16. The first or osseous ray of the anal is rudimental; the fifth spinous ray of the ventral is bound by nearly its entire length to the abdomen by a membrane. The pectoral rays from the second to the sixth exhibit a basal osseous spinous portion, which is not nearly so marked as in the ventrals. The pectorals reach the basis of the latter.

The lateral line is complete and is slightly deflexed opposite the dorsal fin. The lips are thin, and the end of the maxillary bone extends to the line of the front of the orbit. Total length M. 0.071; ditto to middle of basis of caudal fin .0565; ditto to anterior basis of anal fin .040; ditto to basis ventral .021; ditto of head .0145; of muzzle .004; width at posterior nares .006; at middle of pterotic .0078. Color, pure silver for a considerable width above the lateral line. Dorsal region somewhat dusky from minute chromatophore.

Numerous specimens from the San Luis Valley, Western Colorado.

MEDA, Girard.

Proceed. Acad. Nat. Sci., 1856, 192; U. S. and Mexican Bound. Survey, Ichthyology, p. 50.

This genus resembles *Plagopterus* in the absence of scales, while it differs in the absence of barbels and the reduction of the number of teeth of the larger pharyngeal series to 4—4. Girard also asserts twice that the dorsal spine is "articulated," a character not observed by me in any species of the group. His figure of *M. fulgida* represents the ventral radii as articulated; but as there are other points in which it differs from the description, it is probably inaccurate.

MEDA FULGIDA, Girard.

A small species from the Rio San Pedro, a tributary of the Gila, in Southern Arizona.

LEPIDOMEDA, gen. nov.

Dorsal fin originating behind the line of the ventrals, which adhere to the belly by the inner ray. Body scaled, lateral line present. Pharyngeal teeth 4—4 in the inner row. No barbels, premaxillary series complete.

This genus has the physiognomy of *Clinostomus*. The presence of scales distinguishes it from *Meda*. The spinous rays are not articulated.

LEPIDOMEDA VITTATA, sp. nov.

Form moderately stout, the greatest depth (at the first dorsal ray) entering the length to the basis of the caudal fin four and a quarter to a third times. The head is wide and flat above, with decurved pterotics, —and slightly depressed behind the interorbital region. Muzzle obtusely descending, not prominent; mouth terminal and descending to a point below the anterior line of the pupil. Length of head, 3.75 times in total length to basis of caudal fin. Orbit round, 3.75 times in length of head, and 1.3 times in interorbital width. The latter is not uniform, but the middle plane is elevated a little above the superciliary ridges, and separated from them by a shallow groove. Nares sublateral. Teeth, 2.4—4.2. Preorbital trapezoid.

Scales small, covering the whole body, except a space behind the pectoral fin, in twenty-six series above the lateral line, and fifty-six transverse in front of the dorsal fin. Radial formula, D. II. 7; C. 19; A. I. 8; V. 1. VI.; P. 15. There are several peculiarities in the constitution of the spines of the fins in which the species differs from *Plagopterus argentissimus*. Thus the second dorsal spine is wider than the first, and so deeply grooved behind as to represent a V in section; it also extends to the extremity of the first, while it is shorter in *P. argentissimus*. The remaining dorsal spines are less distinctly enlarged and ossified; those of the ventrals are less developed, and their apices, instead of being free, continue into the terminal articulated portion. The pectoral radii

are scarcely enlarged at all. The base of D. I. is nearer the basis of the caudal fin than the end of the muzzle, by the length of the latter to the posterior nares. Caudal fin deeply forked. Total length M. 0.085; ditto to basis caudal fin .0685; ditto to basis anal .047; ditto to basis ventral .0325; ditto of head .018; to orbit .043; width at posterior nares .006; at middle of pterotic .009. Color, silver to half way between lateral and dorsal lines, the upper part of it underlaid by a lead-colored band; a median dorsal black band from front to caudal fin.

Numerous specimens from the Colorado Chiquito river, Arizona, collected by Dr. Newberry, Jr., (5x). The largest species of the group.

LEPIDOMEDA JARROVII, sp. nov.

A species resembling the last in many respects, but differs in a greater elongation of form, weakness of squamation and peculiarity of coloration. The fin radii are similar in number and character, but the dorsal is furnished with more slender spines. The chin projects a little beyond the upper lip when the mouth is closed. The depth of the body at the ventral fins enters the length to the basis of the caudal 5 to 5.25 times, and the head enters the same four times. The eye is larger than in *L. vittata*, entering the length of the head 3.25 times and equalling the interorbital width. The end of the maxillary bone reaches the line of the anterior border of the orbit. The pectoral fin reaches the ventral, but the latter does not attain the vent. The scales are difficult to detect; there are 51 transverse series between the head and the dorsal fin. Total length, M. 0.081; do. to caudal fin .065; do. to anal .0465; do. to ventral .032; do. of head .0165; do. to orbit .0048; width between orbits .005; do. between middle of pterotics .008. Color olivaceous above with a median black vertebral band; sides to above lateral line silvery, leaden edged above. Bases of ventral fins red.

From the Colorado Chiquito river, Arizona. Dedicated to Dr. Henry C. Yarrow, Zoologist of the survey under Lieut. Wheeler (No. 505).

The following species were also obtained by the expedition from Utah Lake, the largest body of pure fresh water in the basin of the Utah, others of equal size being alkaline or salt.

SALMO VIRGINALIS, Girard,

Maintains its distinctness from *S. pleuriticus*, Cope, from the streams which flow from the mountains on both sides, in its more slender form of head and body. The depth enters the length 5.75 and 6 times, and equals the length of the head to the preoperculum. In *S. pleuriticus* of equal size, it enters the length 4.66 times, and nearly equals the length of the head.

COREGONUS VILLIAMSONII, Girard.

SIBOMA ATRARIA, Girard.

The largest of the lake Cyprinidæ, specimens procured weighing one and two lbs.

ALBURNELLUS? sp.

Scales $\frac{14}{\frac{77}{9}}$. Anal radii I. 8—7. Teeth 2.4—4.2 without grinding face. From Beaver River, Lake Utah, and the Rio Grande, in Colorado.

ALBURNELLUS RHINICHTHYOIDES, Cope.

Tigoma rhinichthyoides, Cope. Hayden's Ann. Report U. S. Geolo. Survey, 1871, p. 1473.

Teeth 1.4—4.1. Scales $\frac{12}{\frac{65}{12-14}}$

Abundant at Provo.

CLINOSTOMUS HYDROPHLOX, Cope.

In Hayden's Geol. Survey Terrs., 1871, p. 475. Abundant.

CLINOSTOMUS TÆNIA, sp. nov.

A smaller species than the last, distinguished by the smaller number of anal radii, the elegant coloration and other characters. Body of average proportions, its depth entering the length without caudal fin four and one-third times, and exactly equal to the length of the head. The head is compressed and the lips equal: the mouth is oblique, the end of the maxillary attaining the anterior line of the orbit. The orbit is large, entering the head three times and a fifth, and equalling the width of the convex interorbital space. Scales $\frac{12}{\frac{55}{5}}$, thirty-three in front of dorsal fin; lateral line complete, deflexed between pectoral and ventral fins. Radial formula D. I. 9. A. I. 10; V. 9; P. 11; reaching ventrals, which reach vent. Dorsal first ray equidistant between the basis of the caudal and the anterior nostril.

Total length .073; do. to anal fin .042; do. to ventral .031; do. of head .014; do. to orbit .0036; width to posterior nostrils .004; do. at middle of pterotic .0062. The sides are pure silvery to the lateral line of pores, above which a blackish vitta extends from the end of the muzzle to the caudal fin. Above this is a narrow very white line which extends to the base of the caudal fin, and above this the entire dorsal region is blackish. Fins unspotted.

Numerous specimens from Provo, near the Lake, (No. 666, S.)

RHINICHTHYS HENSHAVII, sp. nov.

An elongate species with small scales and overhanging but obtuse muzzle, resembling a *Cerátichthys* of the group of *C. nubilus* (*Rhinichthys*,) Girard. The depth enters the total length 5.5 to 6 times, the head entering the same five times. Eye 4.3 times in length of head, 1.5 times in interorbital width. The base of the D. I. is intermediate between the base of the caudal fin and the anterior nostril. The ventral fins reach the anal, but are not reached by the pectoral. Dorsal fin originating behind the base of the ventrals. Radii, D. I. 9; A. I. 7; V. 8; P. 12. Scales $\frac{16}{\frac{97}{12}}$. Color white with a few dark clouds on the caudal

peduncle. Inferior fins reddish. The more anterior position of the dorsal fin is one point of difference from *R. maxillosus.*

From Provo; No. 48, a.

Var. II, back dark; a dark band from end of muzzle to caudal fin. Fins and lips red. D. I. 8 Provo; 204 a; 281 a; Colorado Chiquito, 5x., 240 Twin Lake, Colorado. Var. III. Back dusky; numerous large black spots all over the sides and head; fins and lips crimson, D. I. 8, No. 754, from Apache, Arizona.

Hybopsis timpanogensis, sp. nov.

A rather compressed species with mouth obliquely descending, and teeth 2.4—4.2, with strongly developed masticatory surfaces. The lateral line of tubules is imperfect in all the specimens, often only represented by a short series in front of the dorsal fin. In larger specimens it is better developed, and in still larger it may be complete, a point which remains as yet uncertain. In the smaller specimens of *Myloleucus parovanus*, the series is imperfect for a short distance in front of the caudal fin, while it is complete in adults. I have observed the same in the *Hypsilepis anolostanus*, Girard. Scales small $\frac{13}{52}$. The dorsal fin originates a little in front of a line drawn from the base of the first ventral ray. The pectorals do not reach the ventrals, while the latter attain the vent. Radii D. I. 9; A. I. 8; V. 8.

The depth is one-fourth the length, less that of the caudal fin, and the length of the head enters the same 3.66 times. Orbit 3 3 times in length of head, 1.2 times in interorbital width; longer than muzzle. Preorbital bone trapezoid. Total length M .047; do. to basis of dorsal .0215; of head .011; width at pterotics .005.

There is a narrow leaden line from the pterotic region to the base of the caudal, below which the color is yellowish, and above brownish, all dusted with black points. Cheeks silvery. Fins dusky.

Numerous specimens were taken at Provo by Messrs. Yarrow & Henshaw, and at Gunnison (No. 668) by Mr. Klett.

Minomus platyrhynchus, sp. nov.

This Catostomoid belongs to the genus *Minomus*, Girard, as defined by the writer in Hayden's Annual Report of the U. S. Geological Survey for 1870, p. 434. It is of very elongate form, the depth of the body at the dorsal fin entering the total length seven and two-fifths times. The head is short and wide, with expanded and depressed muzzle; its length enters the total five and three-quarter times. The scales are materially larger on the caudal peduncle than on the post-scapular region, and the dorsal fin originates considerably nearer the end of the muzzle than the basis of the caudal fin. Radial formula, D. I. 11; C. 18, openly emarginate; A. I. 7; V. 9 not reaching vent; pectoral reaching half-way to ventral. Scales $\frac{15}{12}$. The orbits are excavated at their superciliary border,

and their diameter enters their frontal interspace 1.66 times, and the length of the head 4.6 times, twice in the length of the muzzle in front of its border. The muzzle considerably overhangs the mouth. The lip folds are tubercular and largely developed, forming a discoidal funnel. The posterior is deeply incised behind; and there is a notch where it joins the anterior lip. The commisure is transverse and abruptly angulate to the canthus, and covered with a cartilaginous sheath as in *Chondrostoma*. Isthmus very wide.

Total length M. 0.168; do. to basis caudal .149; do. to basis ventral .082; do. to basis of dorsal .070; do. of head .029; width of muzzle at mouth .0115; with head at pterotics .0156. Color blackish, belly and ventral fins yellowish (? pink). This species resembles the *Catostomus discobolus*, Cope, but has larger scales, besides presenting generic differences. Several specimens from near Provo. Messrs. Yarrow and Henshaw.

Minomus jarrovii, sp. nov.

A less elongate species than the last, with a much less enlarged muzzle. The anterior scales are smaller than the posterior, and the first dorsal ray is nearly intermediate between the end of the muzzle and the basis of the caudal fin. Radii D. 9; C. 18; A. I. 7; V. 9, well removed from both vent and pectoral fin. Depth at dorsal fin 5.75 times in total length, into which the length of the head enters 5.3 times; orbit small, 4.6 times in length of head; twice in interorbital width, and 1.75 times in muzzle, the latter projecting a little beyond mouth, not depressed, but narrowed viewed from above. Labial folds well developed, tubercular, the anterior rather narrow, the posterior deeply incised. Commissure with acute cartilaginous edge, regularly convex forwards.

Scales $\frac{14}{14}$.

Total length M. .107; do. to basis of caudal .0933; do. to basis ventral .052; do. to basis dorsal .047; do. of head .0205; width muzzle at mouth .075; of head at pterotics .011.

Color light brown with numerous dusky spots and clouds; a narrow abdominal band light; fins and chin ? red.

Two specimens (204a) obtained by Messrs. Yarrow and Henshaw at Provo. Dedicated to Dr. Yarrow, whose zoological explorations in various portions of the United States have been productive of many interesting results.

Catostomus ? generosus, Girard.

U. S. Pacific R. R. Surv. X, p. 221.

From Provo, Utah, specimens of two and a-half pounds weight.

Recapitulation:

The fishes of the Utah Lake above enumerated, number twelve species, as follows:

Salmonidæ.

Salmo virginalis, Girard.

Coregonidæ.

Coregonus villiamsonii, Girard.

Cyprimdæ.

Siboma atraria, Girard.
Alburnellus, sp.
Alburnellus rhinichthyoides, Cope.
Clinostomus hydrophlox, Cope.
Clinostomus tænia, Cope.
Hybopsis timpanogensis, Cope.
Rhinichthys henshavii, Cope.

Catostomidæ.

Minomus platyrhynchus, Cope.
Minomus jarrovii, Cope.
Catostomus ? generosus, Girard.

The following species were obtained at other localities in Utah and Arizona.

CERATICHTHYS BIGUTTATUS, Kirtland.

Baird, Girard, Cope Cyprinidæ of Pennsylvania, p. 366, Tab. xi., fig. 5, var. *cyclotis*, Cope, Proceed. Acad. Nat. Sciences, 1864, p. 278.

Dr. Yarrow obtained a number of specimens of this abundant eastern fish at Harmony, in Southern Utah. This is an unexpected discovery, giving the species the greatest known range of any of our Cyprinidæ, the *Semotilus corporalis* accompanying it to the eastern slope of the Rocky Mountains. The Smoky Hill River was the most western locality for the *C. biguttatus* up to the present time.

CERATICHTHYS VENTRICOSUS, sp. nov.

Allied to *C. henshavii*, Cope, but distinguished by its deeper body and more numerous scales below the lateral line, which exceed in number those above it, contrary to the rule usual in *Cyprinidæ*. Depth at ventral fin one-fourth length exclusive of caudal fin, and a little less than length of head, orbit a little less than one-fourth length of head and 1.33 times in length of muzzle and interorbital width. Muzzle compressed, projecting beyond the horizontal mouth; maxillary bone reaching the line of the anterior nostril. Radii D. I. 7; A. I. 7; V. 7. Dorsal originating behind line of ventrals. Scales $\frac{14}{11}$. The specimens are bleached by the action of spirits, but they appear to have been of uniform color, excepting an irregular dark band from the end of the muzzle to the caudal fin. Length of a specimen to base of caudal M. .061; do. to base of anal .043; do. to base ventral .033; do. to base dorsal .035; length head .0162; width do. between orbits .0045; do. at middle of pterotics .0073. Number cccl; from Arizona.

MYLOLEUCUS PAROVANUS, sp. nov.

With a general similarity to *Clinostomus montanus*, this fish may be readily determined by the generic characters of the teeth and fins, as

well as by the reduced number of radii of the anal fin. The genus *Myloleucus* was established by the writer in 1871* for species resembling *Siboma*, in having the pharyngeal teeth of the longer row 4—5, and the origin of the dorsal fin situated in advance of the ventral, but differing in the possession of well-defined masticatory surfaces on the teeth. The typical species is *M. pulverulentus*, Cope, from the warm springs of Utah, a fish which differs from the present one in the greater stoutness of form and smaller and more numerous scales.

Form moderately stout; muzzle short, conical, lips even, mouth very oblique, maxillary bone reaching anterior line of orbit. Profile of head and back gently arched. Depth of body equal length of caudal fin and measuring 4.25 in the total length less that fin; length of head, 3.5 or 6 in the same. Orbit large 3.1 times in length of head; greater than muzzle, equal interorbital width. Scales $\frac{11}{6}$, the lateral line decurved in front, and continued to base of caudal fin. Radii, D. I. 9; A. I. 8; V. 9. The pectorals reach little more than half way to the ventrals; the latter just attain the vent. Caudal well forked. The color is transparent, with a plumbeous lateral band, the ventral and pectoral fins dusky, the dorsal and caudal shaded with the same. Total length M. 0648; ditto to base caudal, .053; ditto to anal, .038; to ventral, .0288; of head, .014; to orbit, .003; width at middle pterotics, .0064.

Numerous specimens were obtained by Dr. Yarrow from Beaver River, in Southwestern Utah. This stream flows into the Sevier Lake, a very alkaline body of water, in which no fishes were found by the naturalists of the survey.

Clinostomus phlegethontis, sp. nov.

Teeth, 1.5—4.2; body, deep, short; scales larger than in any other species of the genus, viz.: eleven longitudinal and thirty-seven transverse series. There is no lateral line, which may be due to the immature state of the only specimen at my disposal. The depth enters the length without the caudal fin 3.5 times, while the length of the head is counted in the same four times. The orbit is large, entering the head 2.75 times, and .2 greater than interorbital width; in older fishes the orbit will be found as usual relatively smaller. The lips are even, and the mouth quite oblique, the end of the maxillary reaching the line of the orbit. Radii, D. I. 7; A.I. 8; the ventrals originate in front of the line of the dorsal, and extend to the vent, and are not nearly reached by the pectorals. Length without caudal fin, .034; ditto to basis of dorsal, .0186; length of head, .008; width ditto at pterotics, .0038. A broad plumbeous band on the side, below which the color is golden, above it probably translucent in life, with a dusky median dorsal line.

Discovered in Beaver River, Utah, with the *Myloleucus parovanus*, by Dr. Yarrow.

* In Hayden's annual Report of the U. S. Geological Survey, p. 475.

CATOSTOMUS ALTICOLUS, sp. nov.

A stout, rather short species of sucker, with elongate head and narrowed muzzle. The scales are larger behind than anteriorly, and number sixty transverse, and nineteen longitudinal rows. The radial formula is, D. 10; C. 18; A. 7; V. 10, originating below the middle of the dorsal fin, and neither extending to the vent nor reached by the pectoral fin. Caudal with shallow emargination. The depth enters the length with caudal five times, which is three and two-thirds the length of the head. Orbit 4.33 times in head, 1.66 times in interorbital width. The muzzle is long (1.66 times orbit), but is not produced much beyond the mouth, but is truncate and narrowed viewed from above. Lip-folds well developed; the superior pendant, the inferior full but incised to the symphysis, the surfaces tubercular. Vertex flat.

Total length M., .0863; ditto to origin caudal fin, .070; ditto to origin anal, .0546; ditto to origin of dorsal, 0365; width head at posterior nares, .008; ditto at middle of pterotics, .010; color silvery, upper part of sides and back dusky. In specimens of this size the lateral line is invisible, but in adults of eight inches obtained by my friend, J. S. Lippincott, it extends to the basis of the caudle fin.

Numerous specimens from Twin Lake, Colorado, obtained by Dr. J. T. Rothrock, botanist of the survey. This lake is situated in the South Park, at an elevation of 9,500 feet above the sea (no. 120).

CATOSTOMUS DISCOBOLUS, Cope.

(Hayden's Annual Report, U. S. Geological Survey, 1870, p. 435).

Numerous specimens from the Zuni River, Arizona, and from another not specified locality in Arizona, (No. 504), obtained by Messrs. Henshaw and Newberry.

HAPLOCHILUS FLORIPINNIS, sp. nov.

First dorsal ray standing above the second or third anal; formula, D. 10—11; A. 13—14; V. 7. Scales large in ten longitudinal and 29 transverse series. First dorsal ray half as far from base of caudal as from end of muzzle. Length of head 4.66 times in total, a little less than 4 times to basis of caudal fin. Orbit large, 3.2 times in length of head and 1.6 times in interorbital width. Mandible projecting a little beyond premaxillary; one external series of teeth in both jaws larger than the others.

Total length M. .0595; do. to anal fin .0335; do. to basis of ventral fin .027; do. of head .0138; width of head at pterotics .008. Color olive gray, the scales with ochre borders. Fins yellow, broadly edged with crimson.

Numerous specimens from the Platte River, near Denver, Colorado. No. 65. A species with large scales.

URANIDEA WHEELERI, sp. nov.

The only Physoclystous or spinous rayed fish as yet found in the Great Basin of Utah.

Radial formula, D. VII. 17; A. 12; P. 15 all simple; Br. VI. The head is depressed and enters the length minus the caudal fin, three times. Orbit large one-fifth length of head, and twice the width of the frontal interspace. Greatest depth (at first anal ray) 6.75 times in length less caudal fin. Anal commencing opposite the third ray of the second dorsal. Lateral line deflexed opposite last ray of second dorsal. The recurved preopercular spine strong, the decurved small and obtuse. Palatine teeth present; end of maxillary reaching line of pupil. Isthmus as wide as length of muzzle and orbit to front line of pupil. Skin everywhere smooth.

Total length .084; do. less caudal fin .069; do. to anal .042; do. to first dorsal .031; of head .022; width at maxillaries distally .0125; at preopercular spines .0185.

From Beaver river S. W. Utah. The other species of the Rocky Mountains, *U. punctulata*, Gill, has, according to that zoologist a much wider head, especially in the frontal region. This character is well exhibited by specimens in Dr. Hayden's collections.

Dedicated to Lieut. Wheeler, Director of the U. S. Survey west of the 100th Meridian.

ON THE ZOOLOGY OF A TEMPORARY POOL ON THE PLAINS OF COLORADO.

By Prof. E. D. Cope.

(*Read before the American Philosophical Society, March 20th*, 1874.)

Some years ago, Thomas Kite, of Cincinnati, observed an Entomostracous crustacean swimming in a temporary pool of rain-water. A species no larger than a pin's head is abundant in horse-troughs, springs, &c., and belongs to the genus *Cypris*. That observed by Mr. Kite is much larger, and is not known to occur in flowing water. It was named *Limnadella Kitei* by Girard. I have since observed it in Pennsylvania, in rain puddles standing in the ruts of roads in woods; and in New Jersey Dr. Knieskern found it in similar pools alongside of roads in the open country. The wonder naturally is, how strictly aquatic branchiferous animals can be propagated under the circumstances, and how they can be distributed from place to place. A similar species has been recently observed by M. Tissandier in pools in the valley of the Seine. These were left by a flood of the river, and before drying up became populous with a species of the Cypridídæ.

The most remarkable examples of this kind are, however, to be observed on the plains of Kansas and Colorado.

Here rains create temporary pools in depressions of the surface, which may remain for a few days or weeks, but are all dried up by the end of September. Nevertheless, some of them at least swarm with a population of branchiferous crustaceans, worms and larvæ of insects, with the adults, which, in their developed state, come to the surface for air, or live on

the adjacent banks. Observations on a pool of this kind determined sixteen species which lived in or on the water, which had an area of thirty feet by fifteen, and a depth not exceeding a foot. Three of the species were worms, six insects, one arachnid, and eight crustaceans.

The insects were a bluish fly, with a pale bloom, which ran rapidly over the surface, aiding its progress by its wings; a slender beetle, that clung to the submerged stems; two species of actively swimming water-beetles, one beautifully varied with white; and a sluggish, pale-green species, which swam readily. There was also that cosmopolitan boatman who swims on his back, the hemipterous notonecta. One of the worms was delicately striped with lines and rows of dots, another was soft and jointless, and could contract itself into a mere lump or extend itself to considerable length. It was no doubt a planarian, and was of a pea-green color. Another planarian was white, and some of its internal organs showed as a milk-white zigzag figure through the body walls. It swam freely through the water. Of the crustaceans, four were the shelled *Cyprides*. One was very small, short oval, and green; another, still small, was a long oval, straw-colored, and covered with hair; a third was large as a small pea, almost globular, and brilliant green. It was very abundant, swimming in twos and threes among the grass-stems or near the surface. The fourth was a gigantic species, large as the thumb-nail, and of a pale-reddish orange color. It was frequently observed in encounters with others of its species. The water was alive with shoals of what appeared to be at first sight the translucent fry of some fish. On closer examination they proved to be elongate crustaceans allied to the *Branchipus*, their delicately-fringed gills hanging suspended from the hinder segments of the body. They were covered with a jointed coat of mail, and darted about with great activity. They were elegant creatures, with a crimson tail setting off the glass-like clearness of the body. The most singular of these forms is the *Cyclops*. It resembles superficially the king crab of our sea-shores, truly, indeed, in the great buckler or shield covering the head and thorax. It has a single elevation on the middle of the top of the head for two eye windows or corneæ, and an inferior pair of widely-separated eyes look downward to the bottom of the water. The tail or body is soft, jointed, and worm-like, and bears a pair of feelers at the end. These curious creatures swim on the bottom, chasing each other here and there, resembling in their motions and form diminutive cat fishes. Some other forms were minute crimson, and strangely formed creatures. The common arachnid was a round-bodied *Hydrachna*, or water-tick, of a bright red color.

This population evidently has a short life, and it is probable that their existence is only secured by the long preservation of the eggs in the bottom of the dry ponds, which may be readily carried from place to place by winds during the dry season.

COSMICAL THERMODYNAMICS.

By Prof. Pliny Earle Chase.

(*Read before the American Philosophical Society, April 17th*, 1874.)

A committee* has been appointed to invite the participation of Students in the discussion of a paper which will be presented at the coming autumn meeting of the Association of German Naturalists and Physicians. The paper is entitled "*Lösung des Problems über Sitz und Wesen der Anziehung*," its object being the identification of gravitating force with thermo-dynamics, by means of the thermal equivalent and Carnot's law of thermo-dynamic energy.

In compliance with the invitation, and as a contribution to the general theory of unitary force, I submit the following Theses, together with references to portions of my communications to the American Philosophical Society during the past eleven years, in which some of them are practically exemplified and verified.

1. If Force is unitary in its origin, it should be omnipresent in its manifestations.

2. In a supposed universal, material, elastic and therefore slightly compressible, luminiferous æther, we may reasonably look for such omnipresent, primitive manifestations.

3. In a universally undulating æther, any gross inertia of points or particles, must establish special systems of both centripetal and centrifugal undulations.

4. The gross, inert particles, in an æthereal ocean, would be impelled towards each other with velocities varying directly as the sum of their inertias and inversely as the square of their distance.

5. As soon as a revolution is established around the common centre of gravity of three nearly equal particles, under the influence of æthereal undulations, there should be a tendency to discoid aggregation with a central spheroidal nucleus.

6. On account of æthereal elasticity, there should also be a subordinate tendency to aggregation along lines of logarithmic parabolas or spirals.

7. In an infinitely diffused nebulous mass, all work would be internal.

8. In a finite, condensing, nebulous mass, there would be external work, especially manifested in attraction, revolution, and rotation.

9. As condensation progresses, v' (the velocity of revolution of a free equatorial particle) $\propto \sqrt{\frac{1}{r}}$; v'' (the velocity of rotation of a constrained equatorial particle) $\propto \frac{1}{r} \propto (v')^2$; g (the velocity of centripetal impulsion) $\propto \left(\frac{1}{r}\right)^2 \propto (v'')^2 \propto (v')^4$.

*Aurel Anderssohn, President; E. Fritsch; Dr. med. Magnus, privat-docent, Univ. of Breslau; von Schmidt, 1st Lieut. in 6th Regt. Artillery; Dr. med. Ludwig Heymann.

10. The foregoing postulates are all equally true, whether the centripetal impulse originate in a thrust, or in a pull.

11. We have no direct evidence of any primitive pull, but we have evidences of radiating thrusts of light and heat from stellar centres.

12. In all known cosmical motions, the centrifugal and centripetal forces act under such laws of equilibrium, that the apparent pull of gravity may be explained by the difference between external and intermediate radiating thrusts.

13. We know of oscillations in the æthereal sea, propagated with v^{λ} (the velocity of light). The communication of an exceedingly minute portion of that velocity to inert particles, would be sufficient to produce all the phenomena of gravitation.

14. The greatest manifestation of gravitating force in our system (g at Sun's surface) $= 875.618$ ft. $= 875.618 \times 584{,}400 = 511{,}711{,}159$ mean light-waves per second. There being $592\ (10)^{12}$ mean light-waves per second, that force could be produced by $\frac{511{,}711{,}159}{592\ (10)^{24}} = \frac{1}{1157\ (10)^{15}}$ of the mean velocity of each light-wave.

15. If gravity were propagated with infinite velocity, and any inert mass were concentrated in a point, a body falling to that point would obtain an infinite velocity.

16. If gravity is the resultant of oscillations of finite velocity, and if solar rotation, planetary revolution, and solar motion in space, are all resultants of gravitating action, their velocities should all be limited by v^{x} (the velocity of the primary efficient oscillation).

17. In a homogeneous circular disc, of infinitesimal thickness, $g \propto$ distance from centre.

18. If such a disc were revolving in a circular orbit, under the combined influence of tangential and centripetal thrusts, in a slightly compressible æthereal ocean, it should rotate as well as revolve, the limit of possible rotating velocity being v^{x}.

19. If the supposed disc should acquire such a velocity that at the periphery $v' = v'' = \sqrt{gr}$, the same equations would be true for every particle in the disc.

20. In a sphere or spheroid, the superficial centripetal thrusts should produce an increase of density at and towards the centre.

21. The ratio of the rotating action of an æthereal stream on the equatorial plane of a nebulous sphere, to the propelling force of the same stream acting on the spherical surface, is $\pi r^2 : 4\pi r^2$, or $1:4$.

22. In a rotating and revolving star, planet, or satellite, each equatorial particle oscillates in waves which have a height equivalent to twice the distance of the particle from the centre of gravity of the rotating body.

23. If $t'' =$ time of rotation, the integral of the impulses communicated during each rise or fall of the rotation-wave, is $\frac{gt''}{2}$.

24. If the rotating body were to expand or contract uniformly, $v'' \propto \frac{1}{r}$, and $t'' \propto r^2 \propto \frac{1}{g}$; $\frac{gt''}{2}$ is $\therefore$ a constant quantity for each particle.

25. At the trough of the rotation-wave, the accumulated retrograde velocity is exactly equal to the originating velocity of tangential orbital impulsion. In other words, $\frac{gt''}{2} = v^x$.

26. The velocity of rotation would become equal to the velocity of revolution, when the sphere had contracted so that $\frac{gt''}{2\pi} = \frac{gt'}{2\pi} = \frac{v^x}{\pi}$. The limiting velocity of inertial aggregation is, therefore, such as would carry a body through the equatorial diameter of a spheroid, while v^x would describe its equatorial circumference.

27. The elasticity of the æther should give rise to harmonic vibrations, and especially to vibrations which involve multiples of $\sqrt{2}$,* 3,† $\sqrt{.4}$,‖ and $\pi\frac{S}{S}$.

28. In consequence of the harmonic vibrations, there should be a tendency to the establishment of points of inertia, and the consequent aggregation of planets and satellites, at harmonic nodes. Such a tendency is illustrated by the Chladni plates, and the 14th Thesis shows that the supposed cause of aggregation is more than adequate for the production of the supposed effects.

29. The blending of different harmonic vibrations should produce secondary vibrations of a lower order, giving rise to varying orbital eccentricities.

30. The influence of harmonic vibrations should be traceable, not only in planetary positions, but also in their masses, momenta, and moments of inertia.

31. The æthereal action upon inert masses or particles, should be followed by a reaction of the particles upon the æther. Subordinate rotating impulsions should thus be established among the planets, and satellites, and particles.

32. The same harmonic laws which introduce order among the various bodies of the macrocosmic system, should also be operative in various forms of orderly arrangement, within each of those bodies.

*The velocity of fall from infinite distance $= \sqrt{2gr}$.

†Centre of linear oscillation $= \frac{2}{3} l$.

‖Centre of spherical oscillation $= \sqrt{.4}\, r$.

§See Thesis 26.

33. The superiority of the wave-theory over the equilibrium theory of tides, demonstrates the importance of considering the cumulative effect of successive impulses, both in molar and in molecular investigations.

34. The height of the atmosphere is sufficient to give the total wave tide a position identical with the equilibrium-tide, with the crest vertically under the disturbing body.

35. The stratification of the atmosphere, indicated by the various currents, should often produce tides in the lower couches of the air identical in position with the ocean tides, with the trough vertically under the disturbing body.

36. The resultant of the tangential and radial orbital impulses upon the elastic atmosphere, combined with the resistance of the earth's surface, should produce daily barometric fluctuations, of such general form and magnitude as have been observed.

37. All tidal influences upon the atmosphere, whether thermal or gravitating in their immediate dependence, should be modified in accordance with Ferrel's laws.

38. There should be cumulative annual as well as daily barometric tides, and in consequence of the tendency to maintain "equality of areas," the two should be so connected as to furnish data for approximate estimates of the Sun's distance.

39. Local temperature should be a measure of the work accomplished by the various local æthereal impulses. The average temperature of different latitudes should, therefore, be determinable by *a priori* mathematical calculation.

40. The barometric tides, if they are dependent upon elastic æthereal waves, should furnish some indications of the elasticity and resistance of the æther.

41. If the disturbances of the moon and planets upon the atmosphere, are produced through the intervention of undulations, and therefore cumulative, evidences of such disturbances should be found in the cycles of meteorological phenomena. The disturbances should be of a greater magnitude than any that are attributable to mere differential-tidal attraction.

42. The velocity and length of sound waves should bear some definite harmonic relation to the mean velocity of the atmosphere, as well as to the velocity and length of the waves in the primary efficient undulation.

43. The daily and annual variations of magnetic needles, should be similar to those which would be produced by mechanical vibrations simulating the thermal currents in the atmosphere.

44. Harmonic analogies should afford probable bases for astronomical, physical, and chemical anticipations.

45. Harmonic relations should be traceable, between gaseous oscillations relatively to the Sun and any given planet, which are dependent upon the relative masses of the disturbing bodies.

46. If gaseous particles are uniformly distributed along a given line

in consequence of an explosion, a secondary centre of linear oscillation should be established between the primary centre and the centre of gravity, [$\frac{2}{3} - \frac{2}{3}$ of $(\frac{2}{3} - \frac{1}{2}) = \frac{5}{9}$].

47. Planets and satellites, oscillating under the combined action of centrifugal and centripetal forces, and subject to disturbances from mutual interaction, should tend to arrangements analogous to those of the particles in an exploded gas.

48. The force of superficial gravity, at the Sun and at the principal planets, should be in simple harmonic relations to other elements of planetary motion.

49. The laws of mechanical arrangement, in the particles of a homogeneous elastic æther, should give rise to polar forces.

50. The velocity of primary oscillation (Theses 16, 25, &c.,) *which satisfies the foregoing theses, by explaining all velocities which are the resultants of gravitating force, is the velocity of light.*

These Theses seem to me to be all rigorously and mathematically connected with the hypothesis of a universal elastic æther. In my accounts of the successive tentative steps, inductive, deductive, and anticipative, by which I have been brought to their recognition, there has necessarily been much that was crude, and some things that were perhaps merely visionary, but the steps have all led towards the same goal. While endeavoring to learn caution from my mistakes, I have never ceased for a moment to believe that the many harmonies and coincidences which I have pointed out, were indicative of important but unknown laws.

The identification of v^x and v^2, (Thesis 50), is perhaps the most important conclusion of the whole, and its importance may render somewhat fuller details desirable. The common explanation of planetary motions, assumes a primitive tangential impulse and a constant gravitating pull, the resultant of the two forces determining the path at every instant. But it should be remembered that the efficient tangential impulse is by no means the one which was originally communicated; that it, as well as the pull of gravity, is continually shifting its direction, and continually renewed; and that all the known cosmical motions can be as readily accounted for by the impulse of waves upon particles differing in their relative amounts of inertia, as in any other way.

In any case of free orbital revolution around a centre of gravity, every infinitesimal pull of gravitation is assumed to be efficient, in some way or other. If the orbit is circular, the orbital velocity $(\sqrt{gr})$ is renewed, as often as a portion of the orbit, equivalent to radius, has been described. This fact is, of itself, suggestive of equal oscillations, either alternately or simultaneously centripetal and tangential, and it may well justify us in looking for some equally simple relationship to an invariable velocity of primitive and continual impulsion.

The only presumably invariable velocity that we know, being that of

light, and the only mode of viewing gravitating action, under an invariable relation to a uniform velocity, being the one which I have pointed out in Theses 23 and 24, there seems to be an *a priori* probability that v^{λ} may be represented by some simple function of the constant velocity gt'', and that gravitating motion, as well as light motion, may be undulatory. Since gravitating fall acts, in orbital motion, until the sum of successive gravitating impulses has communicated a tangential velocity equal to $\sqrt{gr}$, thus renewing the orbital velocity, it seems natural enough to suppose that the same fall may also act, in rotary motion, until the sum of successive impulses has communicated a centripetal velocity $= v^{x} = v^{\lambda}$, thus renewing the velocity of primary impulsion. If the gravitating thrusts or pulls are supposed to be all efficient, it is not only right, but it is even our duty, as earnest truth-seekers, to try to trace their efficiency as far as possible.

In the oscillation described in Thesis 22, each equatorial particle is alternately approaching to, and receding from, the orbital centre of gravity, during intervals of a half rotation. The integral of gravitating impulses, at the centre of our system, during each wave rise or fall, is, perhaps, as closely identified with the velocity of light, as is the integral of gravitating impulses, during the orbital description of radius, with the orbital velocity. For, from the equation $\frac{gt''}{2} = v^{x} = v^{\lambda}$, we deduce, for the time of solar rotation, $t'' = \frac{1}{2 \times 497.827} \times \left(\frac{1}{214.86\pi}\right)^{2}$. This value differs, *by less than* $\frac{5}{6}$ *of one per cent.*, from the estimate of Bianchi, Laugier, and Herschel, and by less than $3\frac{1}{3}$ per cent. from that of Spörer, which is the lowest estimate hitherto published. From the constant solar equation, $\frac{gt''}{2} = v^{\lambda}$, we readily obtain, by introducing the variable r, the general equation for planetary velocity, $\sqrt{gr} = \sqrt{\frac{2rv^{\lambda}}{t''}}$

The following references are to the published volumes of the Proceedings of the American Philosophical Society, except when otherwise specified. The Arabic numerals, prefixed to each set of references, denote the Thesis which they verify or exemplify.

2. ix. 371, April 15, 1864; ix. 427, 432, Oct. 21, 1864; x. 98, April 21, 1865; xii. 392, Feb. 16, 1872; xii. 411, July 19, 1872; Trans. Amer. Philos. Soc., xiii. Art. VI.

3. xi. 103, April 2, 1869; xiii. 140, 142, Feb. 7, 1873.

4. xiii. 245, May 16, 1873.

6. xii. 518-22, Sept. 20, 1872; xiii. 193, 244, April 4, May 16, 1873.

9. xiii. 146, March 7, 1873; xiii. 243, 245, May 16, 1873.

12. xiii. 193, April 4, 1873.

13–26. ix. 408, July 15, 1864; xi. 103, April 2, 1869; xiii. 148, March 7, 1873; xiii. 245, May 16, 1873; xiv. 111–3, Feb. 5, 1874.

27–32. x. 261-9, Sept. 21, 1866; x. 358, Nov. 15, 1867; xii. 392–400, Feb. 16, April 5, 1872; xii. 403-17, May 16, July 19, 1872; xiii. 140-54, Feb. 7, 16, March 7, 21, 1873; xiii. 193-8, April 4, 1873; xiii. 237-48, May 2, 16, 1873; xiii. 470-7, Oct. 3, 1873; xiv. 111–3, Feb. 5, 1874.

33. ix. 283-8, Dec. 18, 1863; ix. 292, Jan. 1, 1864; ix. 346-9, March 4, 1864; ix. 367-71, April 15, 1864; xii. 178-90, Aug. 18, 1871; *et passim.*

34–5. x. 523-33, Oct. 2, 1868; xii. 180, Aug. 18, 1871; xii. 525, July 19, 1872.

36. ix. 284, Dec. 18, 1863.

37. Mathematical Monthly, i. 140, sqq.; January 1859, and continued in subsequent Numbers, some of the results having been published about two years before, in the Nashville Journal of Medicine and Surgery.

38. ix. 287, Dec. 18, 1863.

39. ix. 346-8, March 4, 1864; ix. 395-9, June 17, 1864; x. 261-9, Sept. 21, 1866.

40. ix. 292, Jan. 1, 1864; ix. 408, July 15, 1864.

41. x. 261-9, Sept. 21, 1866; x. 439, June 19, 1868; x. 530-3, Oct. 2, 1868; xi. 113, May 7, 1869; xi. 203, Oct. 1, 1869; xii. 38-40, March 3, 1871; xii. 65-70, March 17, April 7, 1871; xii, 121-3, May 5, June 16, 1871; xii. 178-90, Aug. 18, 1871; xii. 400, April 5, 1872; xii. 523-9, Oct. 18, 1872; xii. 556-9, Nov. 1, 1872.

42. xi. 109, April 2, 1869; xiii. 150, March 21, 1873.

43. ix. 359, 367-71, April 1, 15, 1864; ix. 427-40, Oct. 21, 1864; x. 98, 111, sqq., April 21, May 19, 1865; x. 151-66, Oct. 6, 1865; x. 358, Nov. 15, 1867; xiii. 153, March 21, 1873; Trans. Amer. Philos. Soc., xiii. Art. VI.

44. ix. 284, Dec. 18, 1863; xiii. 140, sqq., Feb. 7, March 21, 1873; xiii. 237, 252, May 2, 16, 1873; xiii. 470, Oct. 3, 1873.

45. xii. 392, sqq., Feb. 16, 1872; xiii. 142, Feb. 7, 1873.

46–8. xi. 103-7, April 2, 1869; xii. 392, sqq., Feb. 16, March 1, May 16, July 19, 1872; xiii. 140, sqq., Feb. 7, March 7, 1873.

49. ix. 359, 367-9, April 1, 15, 1864; xii. 407-8, May 16, 1872.

50. ix. 408, July 15, 1864; ix. 427, 432, Oct. 21, 1864; x. 261-9; Sept. 21, 1866; xi. 103, sqq., April 2, 1869; xiii. 149, March 7, 1873; xiii, 245, May 16, 1873; xiv. 111–3, Feb. 5, 1874; *et passim.*

SAVING-FUND LIFE-INSURANCE.

By Pliny Earle Chase.

(*Read before the American Philosophical Society, April 3d*, 1874.)

Elizur Wright, the eminent Actuary and formerly State Commissioner of Life Insurance for Massachusetts, has proposed a combination of Saving Fund and Life Insurance, to dispense with the extravagant commissions of canvassers, and with other enormous expenses incident to the present competitive system. If sufficient business could be secured, there can be no doubt that such a combination would work admirably. In order to float a company until a paying business is established, Mr. Wright proposes to start with a capital of $500,000.

But capitalists are timid in regard to untried enterprises, especially when it is proposed to enter a business field without resorting to any of the customary methods for inviting business. It may, therefore, be well to inquire if there be no other way, in which some analogous experiment may be tried safely, cheaply, fairly, beneficially, and in every way satisfactorily.

Life Insurance is the safest of all kinds of underwriting. The risks are known with greater certainty, the contingencies of extraordinary misfortune are fewer, the margin reserved for unforeseen calamities is more liberal, and the interest of the beneficiary in guarding the risk is greater, than in any other of the many forms of protective insurance. The only case in which a guarantee capital would be of any advantage, is when heavy losses occur before sufficient accumulations have been provided to meet them.

Saving Funds, notwithstanding their occasional failure, have long been, and will doubtless continue to be, more popular than Life Insurance Companies. They require no expensive corps of agents or canvassers, and but little advertising, especially if the interest of the benevolent can be enlisted in their behalf. This may be easily done if other advantages are added to those of an ordinary Savings Bank, and especially if the depositors and friends of the Institution can be brought to feel that the money can be withdrawn in case of pressing personal necessity, while, in case of early and unexpected death, the bereft family will be specially benefited. The proper way, therefore, to inaugurate the proposed experiment, would seem to be, to add new inducements to a system that is already cheap and popular, rather than to enter into the field of direct competition with the cumbrous and expensive organizations and appliances which have been thought necessary for the successful working of a system that is costly, and, in many respects, unpopular.

In order to secure such added advantages as I have suggested, I submit the following outline of a plan, which may, perhaps, be so modified by hints derived from the study or experience of others, as to be deemed worthy of practical trial.

1. Credit all depositors with four per cent. simple interest, and give them the right to draw upon their accounts, either under the usual re-

strictions, or subject to such regulations as may from time to time seem desirable.

2. Credit all profits to a general fund for the benefit of the family, or other specified persons, at the death of each depositor, the interest of each contributor, in the common fund, being proportional to the amount of his average deposits.

3. Encourage beneficial contributionships, of stated sums per week, month, or year, for the payment of fixed sums at the time of death, the payments being further guaranteed by a sufficient stipulated tax upon all the survivors.

4. Open accounts in accordance with the ordinary principles of Life Insurance, crediting each deposite with the amount of a fully-paid policy to which it would be entitled. These accounts will facilitate the determination, at the death of each depositor, of his interest in the common fund, and they will prepare the way for a final safe assumption of all the risks of specific Life Insurance, Endowments, Annuities, Tontines, &c.

5. Allow the beneficiaries, if they desire it, to continue their participation in the accumulated profits, for ten years after the death which gives them an interest in those profits.

6. Convince merchants, manufacturers, clergymen, and benevolent individuals generally, that the depositors in the proposed institution will receive a greater return, in case of early death or other unforeseen calamity, than they could obtain from any other source. The voluntary, unpaid recommendations, thus secured, would soon command a large and profitable business.

7. Enlist the co-operation, in the Board of Directors, of men whose reputation for tried integrity and disinterested philanthropy, will be a sufficient guarantee of wise and equitable administrations.

8. Invite an examination, by the wealthy and charitable, of the claims of the Institution for their consideration, and for a participation in their bounty. Contributions thus obtained should be added to a permanent fund, the income being used for the benefit of all the depositors.

After a sufficient capital has been accumulated, all the specific undertakings of Life Insurance and Annuity Companies could be assumed with perfect safety, and with the assurance of larger returns than any Company can now afford. A large amount of the best class of business would come from intelligent, careful men, who are influenced more by their own judgment of the merits of a system, than by the representations of canvassers. There would be no forfeiture, no anxiety from fear of inability to meet the yearly increasing burden of a large yearly premium, no doubtful hesitation about investing the unusual profits of prosperous years, no fears of pettifogging attempts to evade payment in case of death. The young, strong, industrious and prudent, whose risks are least, while their need of insurance, in case of unexpected calamity, is greatest, would contribute so large a part of the deposits, that the accumulations of the benificiary fund would be unusually great, and all the participants would be proportionately helped thereby.

A DOWNWARD ATMOSPHERIC CIRCULATION, AS ONE CAUSE OF EXTREMES OF COLD.

By Lorin Blodget.

(*Read before the American Philosophical Society, May 1st*, 1874).

The system of atmospheric circulation which gives us a general easterly movement in temperate latitudes, scarcely needs further explanation, yet the recent establishment of observatories on Mount Washington and on Pike's Peak, are found to afford positive evidence in verification of such movement that is full of interest. The easterly current on the top of Mount Washingon, at least, is almost constant and with extreme velocity, in a direction the resultant of which is almost due east, and there are no conditions apparent to throw doubt on the general assumption that this is the returning current of a vast system of atmospheric circulation to and from the tropics, primarily, through which the heat and humidity of the tropics are widely diffused at both the northern and southern temperate belts.

But I propose only to refer to some deductions that have for some time past impressed me with great force, as to the origin of certain almost inexplicable facts of our climate, at points near the northern border of this system of circulation; and particularly in the colder parts of the United States, east of the Rocky Mountains, in winter, and indeed, in all the cold months. I had the honor to lay before this Society on a former occasion, some suggestions as to the origin of the extremes of cold observed at various points, chiefly of the northwestern interior, and to express the conviction that these extremes were not propagated, or transferred along the surface, as a part of what is usually thought to be the surface circulation from the west; and also that they do not move down—that is, along the surface—from the north, or from any other point of the compass. On the contrary, they appear to be *instituted or established* at the point of their most extreme existence, as if brought down from the upper atmosphere, or as if the result of the action of causes extraneous to the earth's atmosphere.

The recent extension of observations to the territories of the plains, and to posts on both sides of the Rocky Mountains, has given us a new basis of facts for the discussion of the symmetrical climates of the eastern United States, as I may call them, since their principal changes are usually quite symmetrical;—and it has disclosed the fact that no symmetry or correspondence of phenomena can be traced across the Rocky Mountains, connecting any great storm, or any area of excessive heat, or excessive cold, with any like condition at the east. I have been particularly observant of such facts as I could obtain in regard to this point along the northern belt, for the purpose, first, of tracing, if possible, the origin of the remarkable extremes of cold occurring in Dakota and Minnesota; and have spent much time in examining these cases, with the result of coming to the conclusion that there is absolutely no connection

or movement from Oregon or Washington Territories eastward to the country of the Upper Missouri, or to the line of Red River of the north. There is no progressive march of a refrigerated area, or of a barometric depression, along that line from west to east across the mountains. And the line of separation is far east of the mountains themselves, apparently as far as the Yellowstone, nearly, though of course, there is some partial correspondence of phenomena west of this line, and some general relation of the principal conditions. And here I anticipate the more precise results I hope to obtain, in explanation and corroboration of these positions, in order to put forth a view of the causes of these phenomena which appear to me new, and which I hope others will examine also. It is that in the system of atmospheric circulation before referred to, there must be a general descent of atmospheric volumes to the surface at or near the northern border of the belt;—that this descent may be of masses sometimes large, and depleted of both heat and moisture before they descend;—that descending volumes may come also from the adjacent atmosphere on the north, not containing heat or moisture brought from the tropics;—and that, as a general fact these cold, dry masses of air, sinking quietly, or poured down with force and violence, to spread over the surface as cold and violent winds, do cause many otherwise inexplicable extremes of cold in the winter and spring particularly.

The descent of masses of heavy, cold air, must often be induced simply to fill the void caused by contraction of the volume of air from which rain and snow fall. All along the belt of westerly winds this contraction is going on, and this very rapidly during all the colder months. Moving with a constant motion toward the earth, as well as along the surface, it is only a natural vicissitude of this condition, that the descending mass should, at intervals, be poured, like a mass of cold water, over the border of the humid belt, producing the extremes that so often appear to *strike down from above.*

I do not remember seeing much reference, hitherto, to descending volumes of air on the northern border of this belt of circulation, yet as the trade winds steadily withdraw the air beneath, toward the tropics, it must necessarily return above; and it must descend as it returns. If all these movements were perfectly regular, we should see no spasms of severity, but as, in fact, there are many days of steadily expanding heat in spring, the days on which the contraction occurs are only the more violent. Hence those heavy pouring winds, that bring such severity of cold during the spring months; winds which are neither winds of propulsion, nor of aspiration, but merely the forcing down of cold masses of air from the upper atmosphere, to spread along the surface to some extent, but to be perpetually recruited and renewed from above. An easy experiment will illustrate the condition, by dropping the upper sashes of high windows in a heated room on a cold day,—the downward movement will prove unexpectedly tangible and heavy, and as conspicuously marked, almost, as if water were poured through the windows.

On several occasions during the present month of April, the weather in the seaboard States has exhibited this phenomenon. All of the severely cold weather, for the season, has been *initiated* at the point where its greatest severity was experienced; not being transferred along the surface from any point at the west, or at the north. For many days of the present month (April) these cold and heavy winds have been felt in the country east of the Alleghanies, when in no single instance that I can trace, has there been any connection or conformity of movement from the western or northern interior. Like severity has often existed there, but the fact, and all its relations, was local in this sense, or was not connected or continuous with other districts.

When the enormous friction of atmospheric contact with the surface is taken into account, it must be apparent that there can be few winds of propulsion. I think it may be fairly assumed that the greater number of winds in cold weather particularly, are *winds that descend*, and that to this descent most of their continued force is due. On Saturday, April 11, and Sunday, April 12, the thermometer fell at Washington under the influence of these obviously descending winds until in the night of the 12th it reached a minimum of 19°, while for three days previous no place west of the Alleghanies in the same latitude was below 50°, and the average temperature at Fort Sully, on the Missouri, 1200 feet above the sea, and in latitude 45° north, was as warm as at Philadelphia, at sea level, in latitude 42° N. This remarkable depression of temperature could not have been due to radiation, since all the areas west and north were even more exposed to radiation, being clear and calm; nor was it due to north or northwest winds propagated along the surface, for there had been no cold winds from these points at the west or north for several days. Nor was there any general storm to effect a displacement or shrinkage, at least no storm on the continent. There may have been some general storm, or shrinkage at sea, however, facilitating or inducing *a descent of heavy masses of cold air from above* to supply the partial vacuum.

I venture to assume, therefore, a large measure of influence in causing extremes of cold in these latitudes to the descending volume of air incident to the shrinking and wasting of heat and moisture from the atmospheric current eastward in the course of traversing the continent. Its northern border is perpetually invaded by fitful alternations of displacement; sometimes getting calm and intensely cold, to reduce the temperature in winter to 10°, 20° or 30° below zero; and in spring, when the general accession of heat gives a more free play of the forces, a frequent recurrence of heavy northwest dry winds *poured from above*, and from the north, displacing and condensing the local, or surface atmosphere; and this overflow is almost constantly repeated until the whole system of circulation has been swept beyond our limits at the north, by the advance of summer. During most of the summer months the rarifying and expanding forces prevail so completely, as to remove all these phenomena far to the north, or possibly to another hemisphere.

We shall undoubtedly be compelled to revise our views as to the primary or leading condition of general storms. The barometer is by no means a certain guide, and instances of severe storms with continuing high pressure throughout are frequently recurring. The recent severe storm of Saturday and Sunday, April 25th and 26th. This storm began with the barometer .15 above the mean, and scarcely fell below the mean (of 30. inches) after ten or twelve hours of continued severity, and when at its height here, on Saturday evening. At Pittsburgh, Cincinnati, Louisville, &c., there was also no perceptible depression below the mean, the barometer being generally at almost exactly 30 inches. No storm was anticipated by the signal office, nor were there any evidences such as usually appear, justifying anticipations of a severe storm. Yet few storms have been as severe, the N. E. wind of Saturday night being extremely heavy here, while northeastward, to Nova Scotia, the slow but certain progress continued throughout the day and night of Sunday. On Monday morning, it is true, a considerable barometric depression appears in Maine and Nova Scotia, of half an inch, or more, in places, but this appears to have set in eastward of New York, almost exclusively. The storm was violent and long continued at New York and southward, with very little barometric depression, not enough to warrant expectations of a storm, or any severity of winds. There have been several conspicuous instances of a similar character since the Signal Service observations gave us such excellent opportunities for observation.

I repeat, that the evidence is cumulative in support of the position that the atmospheric movement in the colder seasons in these latitudes is one of constant descent of volumes; that the cold gales of the spring months, strike in at areas east of the Alleghanies from the northwest, when they are unknown west of that line; and occur in repeated instances not only when by no possibility they could be continuous, or connected with like movements propagated from the northwest, but also when the winds, even so near as Pittsburgh, blew all the time in an opposite direction.

The almost inexplicable phenomena presented by the severity, the persistence and force of these winds, with the low temperature they bring, become easy of solution, under the view that their volume is perpetually renewed at all points where they prevail, by constant *pouring from above*, as if a current of cold water was renewed and enforced in its movement by so pouring a stream *downward*, as well as along the surface. On each of the last three days the facts of such forcible descending winds were experienced here, and during the full period of ten days preceding there was, as the Signal Office charts will show, a marked absence of west or northwest winds at all points of the western or northwestern interior, from which it is usually supposed these high cold winds are derived, and propagated eastward along the surface to the Atlantic Coast. In fact, for a week from April 25th to May 1st, the weather was warmer at Pembina, lat. 49° N., than at Philadelphia, in 42° N., being 44° for the 1 A. M. observation at Pembina, to 42° for the same at Philadelphia.

METEOROLOGICAL PECULIARITIES OF NEW ENGLAND.

By William F. Channing, M. D.

(*Read before the American Philosophical Society, May 1st,* 1874.)

For twenty years I have noticed an invariable coincidence between the appearance of ice in quantity on the Newfoundland Banks or neighborhood, and an unusual, often constant rainfall in New England. This rainfall appears to be in proportion generally to the amount of ice, and it is followed, I think always, by a dry period, perhaps a drought of several weeks, the drought apparently having some proportion to the excess of previous rainfall.

The appearance of ice on the Banks or neighborhood varies in different years, from April to June, and the wet spring and summer drought are early or late accordingly. Many years the quantity of ice is small and the disturbance of the rainfall is hardly noticeable. I am aware how many observations are required to establish a meteorological law for any part of the earth's surface. I therefore only venture to ask attention to these coincidences.

There is another obvious peculiarity in the meteorology of the New England coast, due to its geographical position. The projection of Eastern Massachusetts and Rhode Island into the Ocean may be compared to a nose on the Atlantic profile of the country. It happens hence that storms following a course parallel with the coast, but either just inside or outside the coast line, will in the one case pass entirely inside the projecting shore of New England, and in the other, sweep over Eastern New England, without warning, while the rest of the country enjoys average clear weather. From these two proceedings, land storms passing inside, and sea storms extending over the coast from Cape Ann to New London, it results that the weather predictions are more frequently falsified over this region than perhaps on any other part of the coast or interior. And yet no part of the American Coast is more densely thronged with vessels in both the coasting and foreign trade.

It would seem desirable, for the study of the ocean storms, which sometimes thus touch New England, (as well probably as Hatteras), to extend the Signal Service to the Bermudas (by a special cable) and also to Nantucket, and generally to extreme outlaying points on the coast.

NOTE ON THE COLOR OF THE MOON.

By Prof. Persifer Frazer, Jr.

(*Read before the American Philosophical Society, May, 1st, 1874.*)

On the 19th of September, 1873, I presented to the Society certain views which as it seemed to me offered a satisfactory explanation of the change of color undergone by the moon during the passage of the twilight circle over her disc. I stated at that time that since what light we get from the moon is reflected solar light, which so far as we can discover has suffered no change on the surface of the moon, it would be natural to suppose that the color of the light would be the same as that of the Sun's light.

The Sun's light is well known to be orange, and the Moon's in the day time white, while at night the latter exhibits the same color as the Sun, though the light is vastly more feeble.

That this change of color in the Moon depends upon the position of the observer relative to the Sun there can be no doubt, and it is equally certain that the phenomenon is of atmospheric origin, for the moon still remains white for some time after the Sun has set.

If, as Tyndall supposes, the blue color of the sky be due to the scattering of the smaller waves of light by the infinitessimal particles or motes of the upper atmosphere; and if the paths pursued by these reflected blue waves be, as experiment proves, in all directions from all parts of this attenuated matter, the change of color may be easily explained.*

Thus the Sun appears to us orange or yellow, because, of the waves constituting white light, which impinge upon our atmosphere, a greater proportion of blue than of red and yellow waves are scattered. Of these waves thus scattered, a large proportion is thrown out again into space, while what remain are sent in all directions—even directly towards the Sun.

This is *one cause* of the blueness of the sky, if not the only one.

When the Moon is shining at night the same conditions are fulfilled. A small fraction of the Sun's light is thrown unchanged into our atmosphere and suffers the same filtering which his beams in daylight undergo; with this difference, that as the blue rays are very inferior to the yellow in luminousness, the more the *amount* of light is diminished, the brighter relatively to the whole amount will appear these scattered rays; and

*The objection that if the waves of light were thus sifted by tenuous matter, those of least length (or the ultra violet) would impart their color to the sky is invalid because Tyndall has shown, and every one can demonstrate for himself, that the earliest appearance of color in a medium in which infinitessimally fine particles of matter are suspended *is* blue. Vide "Blue color of sky," &c., Tyndall.

thus it happens that in a clear moon-light night the sky is much more strikingly blue than the same sky would be at mid-day.

When the Moon shines in the day-time we must suppose that the rays she sends to us are affected in precisely the same way as at night. If she appear white (as is the case) it must be owing to an addition to this light of the constituents which it has lost, viz., blue. We know that these waves are coming to the eye from every part of the sky, and therefore from that part occupied by the disc of the Moon, and hence the inference is natural that this contribution from the store of the Sun's light just makes up what was necessary to produce white light, and that as this accession can go on after the setting of the Sun, and until the twilight circle has passed over the Moon, the whiteness of the latter will commence to fade as the thickness of shell of direct rays diminishes, and the maximum of deviation from the color (under given conditions of the atmosphere) will be reached just after the Sun has reached a point in the heavens whence the last direct ray tangent to the earth's surface falls in the upper limits of the atmosphere on a line joining the Moon with the eye of the observer.

But there is a practical mode of testing this hypothesis, which is dependent upon the polarization of the sky light in directions perpendicular to the Sun's rays.

When the Moon is in her first quarter she lies in just this direction from the observer; and since the blue light from the Sun, which, added to her own, causes her to appear white, is polarized, the Moon when viewed through a Nicols' prism by day ought to appear orange.

This observation has been many times repeated by me, and the results are precisely those anticipated.

Owing to the fact that there is always some unpolarized light received in this direction the change of color is not quite so marked as is that from day to night, still the change is very striking and unmistakable.

There is another cause for the blue color of the sky which is the effect of contrast in the eye. If all the light which was reflected was white light and very generally diffused over the firmament, the effect of the bright yellow orb of the Sun or Moon would be to tinge this light with blue so far as the subjective phenomenon was concerned. But that this does not explain the whole of the phenomenon is evident from the fact that the blue light obtained by Tyndall from his decomposition tubes was also polarized in a direction perpendicular to the path of the beam.

NOTE ON THE SOMERSET COUNTY COAL BEDS IN PENNSYLVANIA.

By John Fulton.

(*Read before the American Philosophical Society, May 1st*, 1874.)

In a recent professional visit to Somerset county, I obtained a vertical section of a portion of the Lower Coal Measures. As this part of the State has been, until quite recently, shut out from investigation, I presumed that this scale would be interesting, and I respectfully submit it.

The section was obtained from recent coal exploratians, near the village of Garrett, on the Pittsburg and Connellsville Railroad. At this place, the Seral Conglomerate is very clearly developed, rising gently westward on the eastern flank of Negro Mountain.

Negro Mountain, or rather the Anticlinal bearing this name, plows up the middle of the first great basin, dividing it, at this place, into two shallow troughs having their greatest depth of coal measures near Meyer's Mills and Bear Creek—the whole lying between the Alleghany Mountain on the east, and Laurel Hill on the west.

Over the back of Negro Mountain, the coal measures and conglomerate have been swept away, leaving uncovered the red back of this large anticlinal.

Castleman's River cuts deeply across the Negro Mountain anticlinal, unfolding a natural geological section, which has been further elaborated by the railroad cuttings along its northern bank—the whole affording unusual facilities for studying Formations XI and XII, with the posture and stratigraphy of the coal measures shoreing on either flank.

Beginning in the railroad cutting, immediately west of Garrett Station, the Seral Conglomerate can be studied up to its floor. In this cutting, a thin seam of impure coal has been brought to light. It also exhibits a rather unusual plunge of the strata eastward, carrying the measures down 300 feet in three quarters of a mile—with this exception, the measures exist under very gentle dips.

The Conglomerate, in its mechanical structure and general appearance, resembles very closely Broad Top and Clearfield.

I did not obtain its total thickness but examined over 300 feet of it, which indicates a greater depth than at Broad Top.

The floor line is distinctly marked in a bold cliff outcrop, 10 feet deep, of rather massive Conglomerate, slashed with clearage planes.

On this rests a belt composed, at its base, of thin plates of sandstone graduating into shales and blackslate as it approaches the (A) coal seam. The division has been terraced with a flat slope, from the brow of the Conglomerate to the coal seam, profiling the two horizons very distinctly.

The first coal seam rests on a thin floor of fireclay. The coal bed has

two benches, the lower, 18 inches thick, is an impure cannel coal inclining to block structure—the upper is a medium quality of semi-bituminous coal with the well marked columnar structure peculiar to the Alleghany coals.

The interval between this and the next small coal seam is composed of thin plates of sandstones with olive colored shales.

The second workable seam (B) is pre-eminently *the bed* of the Lower system of coal measures. Not perhaps so much from its size and good quality of coal, as from its ready and sure identification, wherever it exists, by the massive bed of limestone on which it rests. The farmers trace it from hillside to hillside, regarding it with peculiar affection as a *double gift*—not only supplying fuel for domestic use, but also lime to enrich the "glades" in their mountain farms.

The coal in this bed is columnar in structure with plates of mineral charcoal disseminated.

In structure and quality it is closely associated with the best Clearfield coal. It will be found a superior fuel for iron working.

The third seam (C) is all pure coal of an excellent quality, but as the bed is high in the measures and does not occupy a wide area in this portion of the field, it has as yet received little attention.

From seam B to the top of the scale the measures are composed of very soft flesh and olive colored shales, which have been rounded and softened into easy rolling slopes and rounded hills.

Some pieces of the blue and drab colored carbonate iron ores of the coal measures were shown me, but their places in the scale were not clearly made out.

The coals from the Lower Measures have thus far only found a local demand. Evidently the time has not come, or the right channel been opened to this great ocean of mineral fuel. It is yet like the Dead Sea, it has no outlet. True, the Pittsburgh and Connellsville railroad has opened channels to the markets east and west, but the law of supply from the large and excellent "Pittsburgh seam," west and east, is found as inexorable as the law of gravity, in holding back the Somerset lower coals, for the present at least.

There is one channel to market which is being discussed, that is, by the opening of a railroad connection of 35 miles from Berlin to Mann's Choice on the Bedford Division of the Pennsylvania Railroad. This would furnish a channel for these coals to flow into market side by side with the Broad Top, Clearfield and Cumberland Coals.

SAXTON, BEDFORD CO., PA., April 17, 1874.

COSMICAL EVOLUTION.

By Pliny Earle Chase,

Professor of Physics in Haverford College.

(*Read before the American Philosophical Society, May* 15, 1874.)

We may reasonably assume, that natural laws which are the most general and the most constant are also the oldest, and that increasing specialization is an indication of increasing, and comparatively recent, development.

The relation of luminous undulation to gravity may, perhaps, be most satisfactorily formulated in the following terms:

At any point in space, perihelion velocity in a parabolic orbit (or its equivalent, the velocity communicated by infinite gravitating appulsion to the same point) *is a mean proportional, between the variable mean velocity of the vector-radial oscillation due to solar rotation,* and the constant velocity of light.* In other words, if $t'' =$ time of solar rotation under a volume of any assumed radius, r,

$$\frac{4r}{t''} : \sqrt{2gr} :: \sqrt{2gr} : v^{\lambda} \quad \therefore g = \frac{2v^{\lambda}}{t''}$$

Since this formula, with the modifications indicated by Thesis 21,† is applicable to all possible orbital motions about the Sun, as well as to solar rotation and solar motion in space, it seems to represent the most general, and, therefore, the oldest physical law yet discovered.‡

Next in point of generality, appears to be the relationship of orbital belts to the point, towards or about which every particle of our system is perpetually oscillating or tending to oscillate, viz., the mean-perihelion centre of gravity of our binary star§ (Sun-Jupiter). The π-series of multiples of the primary radius which is determined by that centre,§ fixes the major axis of solar revolution about the stellar centre of gravity, decides the relative masses of the Jovian and Telluric systems,‖ and groups the planets into pairs, the points of division corresponding with such apsides of Mercury, Earth, and Saturn, as recent investigations have shown to be actually correlated, through mutual planetary interaction.

The next steps in the development of planetary order, were, perhaps, the fixing of an outer limit to the system, at such distance that the passage of a light-wave, from its linear centre of oscillation to the sun, is synchronous with the time of planetary revolution at the Sun's surface;** the establishment of new centres of inertia at harmonic nodes;

* The Sun's volume being supposed to expand or contract, homogeneously, to the given point.

† Proc. Amer. Philo. Soc., April 17, 1874.

‡ ויאכר אלהים יהי אור ויהי אור *Genesis*, i. 3.

§ xiii. 471, sqq.

‖ xiii. 240, (3).

** xiii. 248, *et ante*.

and the determination of orbital eccentricities by the blending influence of linear, circular, spherical, and harmonic undulations.§

It is evident that every planet, satellite, or other rotating and revolving globe, may have its principal motions formulated by the continued proportion,

$\frac{4r}{t''} : \sqrt{2gr} :: \sqrt{2gr} : \left(v^x = \frac{gt''}{2}\right)$; v^x being constant for each body, under every possible variation of g, r, and t''. The various *primary* cosmical velocities having been determined by the general æthereal undulations, and the arrangement of the planets being dependent on subordinate harmonic undulations, we may reasonably look for various *secondary* values of v^x having a similar dependence, indicating a relationship to solar centrifugal impulsion, analogous to that of the primary velocities to æthereal centripetal impulsion, and marking a further progress in development.

The equilibrium of solar centrifugal and centripetal forces, indicated by the equation $v = \sqrt{gr}$, is a maximum at the Sun's surface. This maximum velocity is equivalent to the constant determining velocity $\left(v^x\right)$ for Jupiter and Earth, the controlling planets of the extra-asteroidal and intra-asteroidal belts.

There is still some uncertainty about the value of t'' for any planet but the Earth. But Proctor's discussions seem to leave no room for any important error in the case of Mars, and the lengths of days at Jupiter, Saturn, Venus and Mercury, are known accurately enough to furnish data for satisfactory comparisons. If we compute the values of $v^x = \frac{gt''}{2}$* from the commonly accepted elements, and regard diminishing velocity as an evidence of increasing inertia and lapse of time, the order of planetary development, after the two principal planetary centres had been fixed, appears to have been Venus, Mercury, Saturn, Mars, the inner system, as a whole, being older than the outer.

Evidences of increasing complexity are found, not only in the varied simple relationships to the primary radius,† but also in mutual planetary associations. The points at which the reactionary centrifugal undulations would have communicated velocities equivalent to v^x for Jupiter, Earth, Venus, and Mercury, are all within the asteroidal belt. The cardinal point, that for Jupiter and Earth, is near the outer asteroidal limit, nearly midway between the orbits of those two controlling planets, and at nearly a mean proportionate distance between the Sun's surface and Saturn, as well as between Mercury's perihelion and Neptune's aphelion. Venus and the Moon are related to the Earth, nearly as Neptune and

* If m = mass of any planet or satellite, in units of Sun's mass, we have the general formula $g = \frac{2mv^\lambda}{t''}$, t'' being time of solar rotation for radius r.

† xiii. 246–8. § xiii. 471, *sqq.*

Mercury to the Sun,* and their geocentric motions, as well as the terrestrial value of gt', (t' being the time of orbital revolution), are in simple relationships to the velocity of light.† The determining point for Saturn is in the orbit of Mars; that for Mars, near Earth's perihelion.

My discussions of explosive oscillation§ have indicated a probable dependence of the chemical laws of combination and dissociation, upon the same forces which have determined planetary mass, motion, and arrangement. They may, therefore, help toward the further extension of the study of universal evolution.

The almost inconceivably minute portion of the mean light-wave velocity $\left(\frac{1}{1157(10)^{15}}, \textit{Thesis } 14\right)$ which suffices to explain all the gravitating motions of our system, seems to confirm the theory of M. Lecoq de Boisbaudran, who attributed weight to the longitudinal vibrations of the æther. The views of Cauchy and Moigno, who find in those vibrations the origin of heat, point to a still more complete identification of thermodynamic and cosmical laws, while the enormous excess of apparently unused velocity, may account for Laplace's conclusion that the propagation of attractive force is at least six or eight million times as rapid as that of light.

I am indebted to Abbe Moigno for a copy of Father Leray's "Constitution de la Matière et Ses Mouvements," with a valuable historical Preface by the Abbe himself. This very interesting essay, like the somewhat earlier dynamic discussions of Challis and Norton,‡ demonstrates the plausibility and the adequacy of Newton's æthereal hypothesis. I hope that the accordance of that hypothesis with the *facts* of Nature, which I have pointed out, and the simple mathematical basis upon which I have rested that accordance, may lead other competent analysts to labor in the same field.

Even while ending this note, I find some new and interesting correlations of mass, density, time, and harmonic undulation, which may prove to be important. If we call the distance, at which a satellite would revolve about a planet in the time of the planet's orbital revolution, the isochronal radius, we have:

1. The mass of the Sun, is to the mass of any planet, as the cube of the planet's radius vector, is to the cube of its isochronal radius.

2. The perihelion radius vector of Jupiter, is nearly equivalent to π^2 times its isochronal radius.

3. Jupiter's radius, is to its isochronal radius, as its mass, is to Sun's mass.

4. Earth's isochronal radius is a mean proportional between its own radius and Jupiter's perihelion radius vector.

* xii. 398, (1), 409; xiii. 246-7.

† xii. 392-417, &c.

‡ xiii. 246.

ELECTRICAL SPECTRA OF METALS.

RESULTS OF AN EXAMINATION AS TO THE PRACTICABILITY OF ASSAYING METALS USED IN COINAGE, BY MEANS OF SPECTRUM ANALYSIS, MADE IN AND FOR THE ASSAY DEPARTMENT OF THE U. S. MINT AT PHILADELPHIA.

BY ALEX. E. OUTERBRIDGE, JR.

Communicated to the American Philosophical Society, by MR. W. E. DU BOIS, *Assayer of the Mint, May 15th,* 1874.

It must have occurred to many, when this brilliant method of scientific research succeeded in detecting the presence of metals, in any given substance, even to an infinitesimal nicety, that the next step must be to determine the *proportion* of such presence; in other words, the *qualitative* must certainly lead to the *quantitative*, as in other chemical processes.

The Annual Report of the Royal Mint at London, for 1872, (dated 15th of April, 1873,) contains an official memorandum of Mr. W. Chandler Roberts, Chemist of the Mint, from which it appears that he was engaged in examining this subject, at the suggestion of, and in connection with, the distinguished spectroscopist and astronomer, Mr. J. Norman Lockyer. No decided results had been reached; but Mr. Roberts concluded by expressing the belief "that every effort should be made to render the instrument serviceable in the operations of minting."

The present modes of assaying gold and silver, both in alloys and in ores, have been brought to such perfection, such accuracy, delicacy and dispatch, that it seemed almost a matter of regret to have them superseded or disturbed. And yet, there is something captivating in the idea of a determination, as it were by a flash of lightning, or in the twinkling of an eye, what proportion of gold or silver is present, in any bar, or coin, or native ore. It therefore seemed desirable that our own Mint should maintain its character for examining and adopting real improvements, and not to wait indolently to hear what might be done abroad.

One of the assistants in the Assay Department, Mr. Alexander E. Outerbridge, Jr., had for several years given special attention to spectroscopic studies, both in theory and in practice; and to him therefore, the subject was committed; with what propriety and what success, will sufficiently appear from what he has written. This will be found in the two following communications addressed to the Assayer.

The details he has given are well worth a careful study; but we cannot help noticing, in a few words, the astonishing paradox at which his experiments arrive; namely, that this method is, in one respect, by far too sensitive and minute; and in another respect, far from being minute enough, to serve the uses of assay. It was worth all his patient labor many times over, to come to this conclusion; as we must come in the present state of this branch of science. And it is likely, that the natural and necessary imperfections of metallurgy, the want of complete atomic homogeneity in the mixing of metals, will forever prevent the spectroscope from taking the place of the present methods of assay.

As Mr. Outerbridge has been careful to give facts rather than suppo-

sitions, he has omitted any explanation of the anomalous results in the final part of his report. And yet it seems evident that where two metals are present, the spark will to some extent elect for its vehicle the one which is most rapidly vaporized. This is notably shown in alloys of gold with copper. It is also very striking in the alloy of nickel and copper, of which our five-cent piece is made. The nickel, which constitutes one-fourth, controls the color of the alloy entirely; and yet, being far more difficult of fusion than the copper, scarcely shows a trace in spectrum analysis. This result is particularly regretted, because a shorter way of assaying this mixture for coinage is very desirable.

These experiments, it is believed, will be of use to show what may, and what may not, be expected from the spectroscope in the way of analysis where several metals are components. They may also be of use in other departments of investigation. D.

Philadelphia, October 30, 1873.

Wm. E. Du Bois, Esq.,
Assayer U. S. Mint.

Sir:—In pursuance of instructions received from you, to examine the subject of the "Electrical Spectra of Metals" with a view to its possible application to assaying, I beg respectfully to report, as follows:

With a small induction coil, and with a two-prism Browning Spectroscope, I tried some experiments to obtain the effects recently discovered by Mr. J. Norman Lockyer, of England, viz., the discernment of differences in the lines of the Spectra of different Alloys of Gold and Silver. In other words, to utilize the Spectroscope as a means of *quantitative*, as well as of *qualitative* analysis.

I had several interviews with Professor Barker, of the University of Pennsylvania, (a recognized authority on the Spectroscope), who had recently met Mr. Lockyer in England, and to whom I am indebted for valuable information pertaining to the subject.

I soon found that although I was able to distinguish clearly between the spectra of pure gold, 1000 fine, and of an alloy of gold and copper 900 fine, inasmuch as the copper lines appeared in the one case, and not in the other, the induction coil was quite inadequate in its length of spark to exhibit any appreciable differences between two alloys of gold and copper. I then applied for, and was accorded by my friend President Morton, of the Stevens Institute of Technology at Hoboken, the privilege of conducting my experiments at that Institution.

Professor Morton most kindly placed at my service the elaborate apparatus in his collection; and I visited New York on Monday last, the 27th inst., returning this evening.

During these four days, I experimented very critically with known alloys of gold, silver and copper, previously prepared for this purpose, and I obtained some very interesting results. Many practical difficulties

presented themselves in the outset, and it was some time before I succeeded in obtaining a special adjustment of the apparatus appropriate to my purpose.

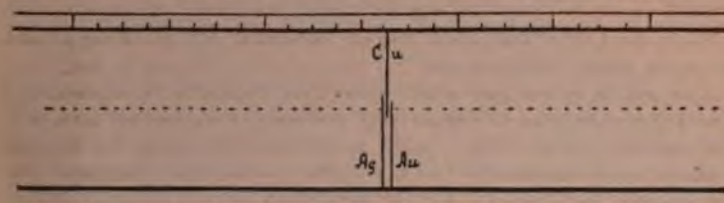
Using one-half of the largest Ritchie induction coil, throwing a spark of eleven inches, (fed by a powerful battery and reinforced by four large condensers) in connection with a two-prism Browning Spectroscope, I found that upon gradually separating the metallic electrodes, certain of the lines *broke in the middle*; and, upon further increasing the distance between the electrodes, the hiatuses in the spectral lines increased proportionately, *but unequally with different alloys.*

This, as I am informed, is the novelty in spectroscopic research, discovered by Mr. Lockyer, upon which the theory of possible quantitative analysis is founded, and I was much gratified at having verified the experiment.

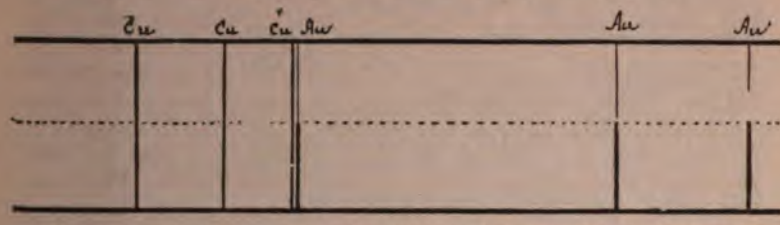
Repeated trials with various alloys, gave similar effects. Having proved this general incident, a systematic series of experiments with alloys enabled me to map the difference of fineness between specimens 500 and 750 fine and even to recognize the variation between ingot-slips 895 and 902 fine. These results were observed by Mr. Andrew Mason, of the New York Assay Office, and by several members of the National Academy of Sciences, then on a visit to the Stevens Institute, as also by other gentlemen, to whom some of the experiments were shown. The variation within seven thousandths above referred to, was by no means marked—indeed, over-cautiousness prevents my relying upon its certainty —although a more delicate adjustment of apparatus and further experience would probably render the distinction more decided. Of course, in these experiments, it was necessary to eliminate the numerous air lines which appeared in all the spectra. A difficulty which presented itself in the exact comparison of certain characteristic lines of gold, silver and copper, whose positions in the spectrum are in close proximity, was overcome by using a pure metal as one electrode and another pure metal as the other electrode. The effect thereby produced was very curious. With pure gold and pure copper as the electrodes, the gold lines extend across only one-half the field of the spectrum, and the copper lines extend across only the other half, the medial termini of both sets of lines being perfectly sharp and bright. By this means a double spectrum of copper and gold is obtained, or rather, a section of a complete gold spectrum and a section of a complete copper spectrum are visible in immediate juxtaposition, thereby enabling a most accurate comparison of lines, which in reality are not identical in position, but which by the previous method were apparently so.

By a slight modification of the experiment, substituting pure copper as one electrode and an alloy of silver and gold as the other, the proximate lines of these three metals are presented mapped, as it were, on a

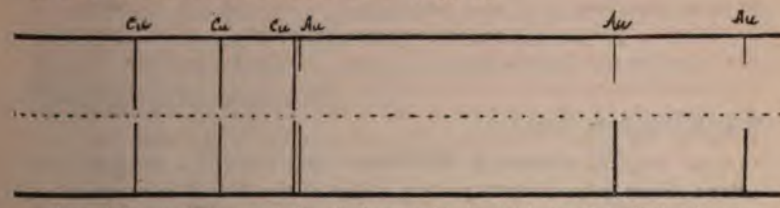
natural scale. Further modifications of this principle suggested themselves and were tried with indications of valuable results. (Fig. 1.)



By using as one electrode, an alloy of gold and copper of comparative fineness, and a baser alloy of the same metals as the other electrode, a result not before observed presented itself. The lines of both copper and gold crossed the entire field of vision, but in the section representing the fine alloy, the gold lines were strong and bright, while in the section representing the base alloy the gold lines were very faint. (Fig. 2.)



By now gradually increasing the distance between the electrodes, the faint gold lines of the base alloy cease to join their bright counterparts of the fine metal at the central line. (Fig. 3.)



The intervening space is at first minute, but as the electrodes are further separated, the ends of the faint lines gradually recede towards the outer edge of the spectrum until they finally disappear altogether. A scale was constructed of the distances at which the electrodes were withdrawn during the several trials, and careful notes were made, but time did not permit an elaboration of these experiments by accurately testing the results when alloys of approximate fineness formed the electrodes. I had wished to use a spectroscope of greater dispersive power, (in order to observe as many distinct lines as possible), and also to magnify the lines by projecting the spectrum through a lantern upon a screen.

The general principle was satisfactorily proved, however, that where two alloys of different grades are subjected to this treatment, the gold lines of the baser compound are noticeably the fainter of the two, and, what is more important, they may be reduced in length by separating the poles, until they disappear.

This points to the possibility of the future application of Spectrum Analysis to Assaying, at least as a test method. For, if an alloy of absolute known fineness were adopted as one electrode, and an ingot-slip assayed by the old process to an equal grade of fineness were inserted as the opposite electrode, in case the assay were correct, the gold lines in both sections of the spectrum should appear of equal brightness, and more especially, should begin to recede from the central line of the spectrum at the same moment, and should disappear at the same moment.

The spectra being inevitable natural effects of physical causes, a variation between two specimens of supposed equal fineness would, in theory, be necessarily indicated by the respective lines failing to correspond in their reciprocal action. To use the method as a means of original assay, it would be necessary, among other things, to construct scales of delicate measurement which, if possible at all, could only be done by a long course of laborious investigation.

The experiments of which the foregoing is a resumé, involved many matters of practical detail to which it is unnecessary to allude, and having been conducted at short notice and within the brief period of four days, they must be considered as simply preliminary.

Respectfully submitted,

ALEX. E. OUTERBRIDGE, Jr.

Philadelphia, May 5th, 1874.

WM. E. DU BOIS, ESQ.,

Assayer U. S. Mint.

SIR :—Since submitting to you my report of the 30th of October last, I have continued at intervals the investigation of the "Electrical Spectra of Metals," with a view to the practical application of the spectroscope to Mint assaying.

Having repeated and proved the correctness of the experiments previously recorded, using a three-prism spectroscope and an induction coil capable of throwing an eight inch spark, (kindly furnished me by Dr. R. E. Rogers of the Medical Department of the University of Penna.) I found it necessary to devise a special apparatus for manipulating the electrodes when under examination. This was made for me by Mr. Saml. James, the machinist in the Mint, and admirably fulfilled its object. A photograph and description of it are appended hereto. Its peculiarity consisted

in an automatic combination of accurately proportioned screws, acting in opposite directions, by which a single motion of the hand sufficed to cause the upper and lower electrodes to approach or recede from the central line of contact in an equal degree. The electrodes, which consisted of small strips of metal cut to a point, were held by a suitable arrangement on the outer circumference of two metallic rings insulated from each other, the upper one slotted to receive a series of twelve electrodes of varying *known* fineness, and revolving horizontally, so that each electrode might in turn be adjusted to face a single electrode of *unknown* fineness fixed on the lower ring. Its object was to admit of the electrodes being separated to any desired extent, while preserving the line of vision, through the spectroscope, directed to the centre of the spark. This is a point of much importance.

A systematic series of experiments was now commenced, in which the behavior of the more volatile metals was at first studied, viz: Lead, Zinc, Bismuth, Tin, Antimony, Cadmium, Mercury, Aluminium, &c. All these give more decided spectra than the less volatile precious metals, and some interesting results were noticed. Approximate illustrations of some of these spectra are appended.

Proceeding to the examination of gold alloys, and starting with base poles—making the lower pole 250 fine and the upper pole 500 fine—the gold lines from the upper half were both longer and brighter. Now substituting in place of the 250 pole one 700 fine, the lower half showed the brighter gold lines. Then, changing the 500 pole for one 800, the brightness of the gold line was again reversed. This alternating effect may be continued, decreasing in degree as the fineness of the poles approach more nearly together, until both poles are of the same fineness, when the lines will be equal in length and intensity.

These experiments proved satisfactorily that comparatively wide variations in the composition of gold alloys were discernible. I now had prepared at the Mint a series of graduated alloys of more approximate fineness, viz:

GOLD AND COPPER.	GOLD, SILVER AND COPPER.
938.	940.1
917.	918.7
906.	866.8
888.3	888.
883.5	884.1
876.5	883.

These alloys were carefully prepared and assayed closely.

With one electrode pure gold and the other 938 fine, the difference between the respective spectra was of course very marked, the copper lines appearing in the one and not in the other. Substituting for the pure gold the alloy 876.5, the difference was still very marked, for, although both gold and copper appeared in each, the copper lines were much brighter and somewhat longer in the baser alloy, while the gold lines were

brighter and longer in the finer. But on comparing the alloys 876.5 and 883.5, (reducing the variation to seven thousandths) I was both surprised and disappointed to find the visible difference of result but slightly appreciable. And the same with regard to the alloys 883.5 and 888.3, and the same with other alloys with equal or less comparative variation of fineness. A variation of one-thousandth, required an effort of the imagination as well as of the eye to detect any difference whatever. And, although I endeavored to map an apparent difference between alloys varying two-thousandths, it would certainly not have been a safe test on which to base an assay. Frequent repetitions with changes of adjustment were tried, the battery power varying from one to six Bunsen cells, in connection with Leyden-jars varying from one very small jar (improvised out of a test-tube) to fifty large jars, (representing a metallic superficies of many square feet) with variations of the distance of the electrodes apart, and with and without the use of a condensing lens, but all these failed to give closer results.

It is true, that these changes of conditions produced certain variations in the effects observed—as, for instance, it was noticed that an increase in the Leyden jar surface always lengthened the lines—the distance between the electrodes and all other conditions remaining the same—while a decrease in the condensing surface had an opposite effect. Thus, to take the extreme cases, with the single small Leyden jar above referred to, and one cell of battery, the lines broke when the electrodes were not more than $\frac{1}{16}$ of an inch apart, and disappeared entirely on separating the points $\frac{1}{8}$ of an inch.

With fifty Leyden jars and six cells of battery, it was found impossible to break the lines at all, even by removing the electrodes to the extreme limit of the spark, and in this case new lines also appeared.

Other variations occurred; such as a momentary irregularity in the length and brightness of the lines, under a strong battery power, owing to the unequal action of the spark;—a difference in the action of the gold lines dependent upon the nature of the alloy, silver tending to lengthen them more than an equal admixture of copper;—the length of the lines is also dependent upon the distance between the spark and the slit (when the latter is used without the intervening condensing lens);—moreover, the eye itself is liable to become confused by continued comparisons of very slight differences. The above and other modifications, so far from solving the problem of close work, rather indicated possible sources of error.

Another element of the process suggested itself to me as likely to render the results uncertain for the practical purpose of assaying, viz: whether the quantity of metal vaporized and giving the spectrum is not too infinitesimal to give safe results for a large melt. This would be affected by the least want of homogeneity in the metal. This is a serious consideration, and with the view partly to search for unknown sources of error and partly to ascertain generally the quantity of metal operated on

in a spectroscopic assay, (should that ever be possible) the following experiment was tried. Having weighed small electrodes, averaging 18 milligrammes each, with the greatest possible accuracy on the gold assay balance of the Mint, (which is sensitive to a twentieth of a milligramme, or even less,) and having arranged a spark register, I found that 1000 sparks might be passed between these poles, each spark showing the spectrum of the metal distinctly, and yet the loss in weight was too small to be made the base of calculation. Thus, a gold pole lost in weight after passing 1000 sparks, $\frac{1}{1000}$ of a grain; this gives for each spark $\frac{1}{1000000}$ of a grain of gold, producing a bright spectrum. I increased the number to 3000 sparks as the test. The loss of weight depends of course upon the electric volume, and in the experiments tabulated I endeavored to keep the latter constant. A slight deposit of the vaporized metal from the opposite pole takes place in fine division, but this is easily removed—in the case of copper and gold poles by dipping the gold for a moment in weak acid, or by gentle rubbing. The annexed tables (marked A and B) show that the loss in weight is marvellously small, averaging less than seven-tenths of a milligramme of gold for 3000 sparks. To give the amount for each spark, this must be divided by the number of sparks; thus, in round numbers an electrode loses $\frac{1}{1000}$ of a grain after passing 3000 sparks; or for 1000 sparks $\frac{1}{1000}$ of a grain, or for each spark $\frac{1}{1000000}$ of a grain. The exceedingly small quantity of metal thus assayed renders this process, to my mind, inapplicable to the operations in the Mint; for it is necessary to determine gold assays to the $\frac{1}{10000}$ part of the normal assay weight, and it is hardly conceivable that a discrimination to the $\frac{1}{10000}$ part of the spark assay weight, or the $\frac{1}{10000000000}$ of a grain is practically possible. Even if it were, it would not be proper to assume that a test on such an atomic scale would correctly represent the value of a large deposit, or even of gold ingots. It would certainly not be in the case of silver, which segregates.

The table of loss shows another curious and unexpected result, viz.: that the loss in weight of the volatile metals very slightly exceeds and in some cases does not equal the loss of the less volatile metals. Thus, in three different experiments of 3000 sparks each, copper loses but .1 M. while gold loses .5 M. It must be remembered that in these experiments a much stronger spark was used than was necessary to show a visible spectrum. When reduced to a minimum, as was done in the case of the miniature Leyden jar, which still gave a distinct spectrum, the loss in weight after 3000 sparks, for silver, copper and tin, was absolutely inappreciable on the balance.

An unexplained anomaly was also noticed in relation to the sensitiveness of the spectroscope to the metals present in small quantity. Although Mr. Cappel has shown, by passing the spark through weak solutions of pure metals, that $\frac{1}{4000}$ of a milligramme of gold will show a spectrum, (it is even less than $\frac{1}{4500}$ of a M. according to an experiment performed by the method described above) yet a comparatively large proportion of

gold may be present in an *alloy*, the presence of which will not be indicated at all by the spectroscope.

In a slip composed thus :..... the spectra of silver and copper are alone visible.

Silver,	708	parts.
Copper,	254	"
Gold,	38	"
	1000	

In fact, in an alloy of gold and copper containing from 200 to 250 parts of gold, the gold spectrum is barely visible. In the case of gold containing copper, it was found that one per cent. of the latter sufficed to show the copper spectrum; likewise in an alloy of nickel and copper containing 20 per cent. of nickel, its spectrum is not visible.

If the spectroscope fails to reveal the presence of anything less than 200 parts of gold in a base alloy, even a theorist must admit that one could scarcely expect to be able to discriminate with certainty a variation of $\frac{1}{10000}$ in a fine alloy.

It is not impossible that future discovery may succeed in explaining this anomaly, in harmonizing the apparent inconsistencies, in eliminating the sources of error, and in reducing the operation to practicable certainty, but in the state of spectroscopic science as it now exists, so far as I have been able to perceive, I have arrived at the opinion, not without regret, that assaying by means of spectrum analysis is impracticable for the purpose of Mint operations.

In conclusion, it should be stated that the principal part of my work was performed at the University of Pennsylvania, with the benefit of the excellent apparatus and appliances afforded in the new and magnificent college building. For this privilege, and also for many valuable suggestions and for personal favors, I desire to acknowledge my indebtedness to Professor Geo. F. Barker of that Institution.

Very respectfully, yours,

ALEX. E. OUTERBRIDGE. Jr.

TABLES.

First column shows the weight of the metallic-electrodes in milligrams before passing the sparks.

Second column shows the weight after passing 3000 sparks.

Third column shows *total* weight of metal volatilized (in fractions of a milligramme).

Fourth column shows the amount of metal volatilized by *each* spark (in fractions of a milligramme).

Fifth column shows the amount of metal volatilized by each spark in fractions of a grain troy.

A

		1	2	3	4	5
*Upper Pole.	Gold	16.6	15.9	.7	$\frac{1}{4280}$	$\frac{1}{277000}$
Lower "	"	16.7	16	.7	"	"
Upper "	Copper	18.5	18.4	.1	$\frac{1}{30000}$	$\frac{1}{1940000}$
Lower "	"	"	"	.1	"	"
Upper "	Gold Ingot,	24	23.4	.6	$\frac{1}{5000}$	$\frac{1}{324000}$
Lower "	" "	"	"	"	"	"
Upper "	Tin	20	19.6	.4	$\frac{1}{7500}$	$\frac{1}{486000}$
Lower "	"	"	19.4	.6	$\frac{1}{5000}$	$\frac{1}{324000}$
Upper "	Silver	24.8	24.6	.2	$\frac{1}{15000}$	$\frac{1}{976000}$
Lower "	"	25.1	25.	.1	$\frac{1}{30000}$	$\frac{1}{1940000}$
Average.	Lead	91.6	90	1.6	$\frac{1}{1870}$	$\frac{1}{121000}$

B

Upper.	Gold	20.5	20	.5	$\frac{1}{6000}$	$\frac{1}{388000}$
Lower.	Copper	10	9.9	.1	$\frac{1}{30000}$	$\frac{1}{1940000}$
Upper.	Gold Ingot	21	20.4	.6	$\frac{1}{5000}$	$\frac{1}{324000}$
Lower.	Copper	20.2	20	.2	$\frac{1}{15000}$	$\frac{1}{976000}$
Upper.	Silver	6	5.8	.2	$\frac{1}{15000}$	"
Lower.	Tin	20	19.4	.6	$\frac{1}{5000}$	$\frac{1}{324000}$
†Upper.	Nickel	12	11.95	.05	$\frac{1}{60000}$	$\frac{1}{3880000}$
Lower.	"	12	11.9	.1	$\frac{1}{30000}$	$\frac{1}{1940000}$

*NOTE—The upper pole usually formed the positive electrode.

†NOTE—The *minimum* of metallic Nickel producing a spectrum according to Cappel's tables is $\frac{1}{600}$ of a milligramme.

DESCRIPTION OF FIGURES 1 AND 2.*

A is a cast-iron base supporting the brass stem C which has a thread cut upon its lower end in order that it may be raised or lowered in the base A and firmly held in position by the jam nut B.

Into the stem C, a secondary stem D is screwed; this may be raised or lowered in stem C by turning the hand-wheel GH.

Upon the upper end of the *secondary* stem D is fitted a cylinder composed of the metallic band FF and the insulating centre G. This cylinder is held in position by the collars on either side, and is kept from rotating by a pin passing through the upper collar and sliding in a slot in the *third* stem E.

Through the stem C and secondary stem D passes a third stem E of steel, having upon its upper end a cylinder similar to the one before described, except that it is slotted to receive twelve strips of metal, while the lower cylinder is slotted to receive one strip. This cylinder is free to turn upon the stem E, and is fixed at any point by the nut upon the end of the stem.

The stem E is prevented from turning by a pin sliding in a slot in the lower stem C.

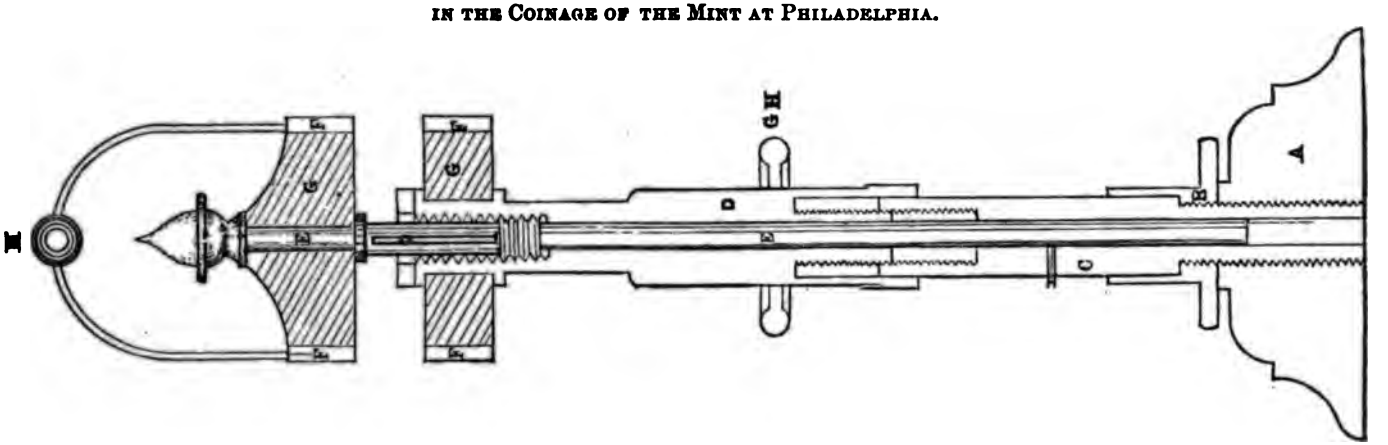
The pitch of the screw upon the stem E, is twice that of the screw on the lower end of the secondary stem D. In turning the hand-wheel GH in either direction, the stem E with the upper cylinder, though moving over twice the distance of the lower cylinder, yet moves an equal distance from a *central point between the two cylinders*, because the lower cylinder in moving from the central point carries with it the upper cylinder. It is to overcome the distance lost that the pitch of the screw upon the stem E is doubled.

The lower portion of the secondary stem D is divided into 24 degrees. A movement of a degree separates the electrodes $\frac{1}{288}$ of an inch.

*NOTE—Fig. 2 is reproduced by Mr. Carbutt. of Philadelphia, from the original drawings according to a modification of the Woodbury Photo-relief process.

With Fig. 2 are given in this No. of the Proceedings, and by the same process, fac-similes of two sets of drawings of spectra of various alloys described in the above memoir.

FIG. 1.—SECTION OF INSTRUMENT USED BY MR. ALEXANDER E. OUTERBRIDGE, JR., IN HIS SPECTROSCOPIC ASSAYS OF METALS USED IN THE COINAGE OF THE MINT AT PHILADELPHIA.



Stated Meeting, May 1st, 1874.

Present, 17 members.

Vice-President, Mr. FRALEY, in the Chair.

Letters accepting membership were received from Dr. W. Camac, dated Philadelphia, April 30th; from Mr. Frank Thomson, dated Altoona, April 28th; from Prof. C. A. Young, dated Dartmouth College, Hanover, N. H., April 22d; from Mr. Raphael Pumpelly, dated Newburg, N.Y., April 22d.

A letter announcing the death of his father was received from M. C. Quetelet, dated Brussels, April 2d, 1874.

A letter, dated 12 Queen Victoria street, London, E. C., April 14th, was received from Mr. Fairman, Editor of the *Eastern Echo.*

A letter from Mr. R. Patterson requested the members of the Society to inspect his copy of Mrs. Peale's "Memorial Volume," of which only twenty-five copies had been printed for private distribution. The folio which lay upon the table contained 81 plates, representing 1,153 specimens of relics of the Stone Age, found in Europe and America, and collected and mounted in the cabinet of the late Mr. Franklin Peale, of Philadelphia, a member of the Society. These plates are all photographs, described in a catalogue prefaced to the volume. As Mrs. Peale has declared her intention to present the cabinet itself to the American Philosophical Society, no copy of the volume is reserved for the the Library.

A letter requesting the use of books was received from Mr. Blasius, and, on motion of Mr. Whitman, the Librarian was authorized to loan such books on Meteorology as Mr. Blasius needed for his investigations, taking proper receipts for their safe return.

Donations for the Library were reported from the Academies at Berlin and Brussels; the Annales des Mines and Revue Politique; the Royal and R. Astronomical Societies;

London Nature; and Mr. Prestwich; the Essex Institute, Boston Soc. Nat. Hist.; Boston Public Library; American Antiquarian Society; Mass. School for Idiots; Harvard College; Mus. Com. Zoölogy; American Chemist; Dr. Raynold Coates; Prof. Cope; McCalla & Stavely; Pennsylvania Board of Public Charities; Buffalo S. N. Soc.; University of South Carolina; and Mr. Michley, of Pennsylvania.

The death of Prof. John Phillips, of Oxford, was announced by the Secretary.

On motion, the Publication Committee was discharged from the consideration of Dr. Allen's paper, and Messrs. Whitman, Lesley and Brinton were appointed a Committee to report to the Society upon the cost of its publication.

Dr. C. M. Cresson communicated the results of analysis of coal from the different benches or layers of the Mammoth bed, with a comparison of their heating powers, &c., illustrated by diagrams.

Mr. Chase communicated, through the Secretary, a letter from Dr. Wm. F. Channing, of Boston, on the need of additional signal service at the Bermudas and along the New England archipelago.

On motion, a copy of the communication was ordered to be sent for the consideration of the U. S. Bureau S. S.

Mr. Lorin Blodget exhibited on a chart of the United States a centre of maximum sudden variation in temperature during the winter months, and explained his views of the cause of the phenomenon.

Prof. Houston, Mr. Briggs, Dr. Emerson, Mr. Lesley, Mr. Whitman, and Gen. Stokes joined in the discussion which ensued.

Dr. Emerson ascribed the gradual translation southward of the peach-belt of the Atlantic coast to the progressive removal of the forests, exposing the fruit to severe variations of climate.

Gen. Stokes showed, by his experience in peach planting on limestone soils, and by the later development and long

fruitful life of his large old trees, that the chemical constitution of the soil must be considered an element in the problem.

Mr. John Fulton, of Saxton, communicated, through the Secretary, a new and more complete section of the coal beds of Somerset Co., Pa.

Prof. Fraser communicated a statement supplementary to his observations in September last on the color of the moon.

Mr. Fraley reported the receipt of the last quarter's rentes from the Michaux Legacy investment

And the meeting was adjourned.

Stated Meeting, May 15th, 1874.

Present, 13 members.

Vice-President, Mr. FRALEY, in the Chair.

Dr. W. Camac, a new member, was introduced to the presiding officer, and took his seat.

A letter declining membership from inability to attend the meetings was received from Mr. J. C. Browne, dated 907 Clinton street, Philadelphia, May 1st, 1874

Letters of acknowledgment were received from the U. S. Observatory, Washington, May 4th. 1874 (II., V,, XII., XIII., XIV., XVI., 69, 70, 71, 73, to 91); the New York Historical Society, May 11th, 1874 (XV., i.); Holland Society, Harlem, March 1st, 1873 (XIV., iii., 87); R. Academy, Lisbon, March 26th, 1874 (88, 89); and R. Observatory, Prague, February 4th, 1874 (88, 89).

Letters of envoy were received from the R. Academy at Amsterdam, Nov. 15, 1873, and the H. Society at Harlem, March, 1873.

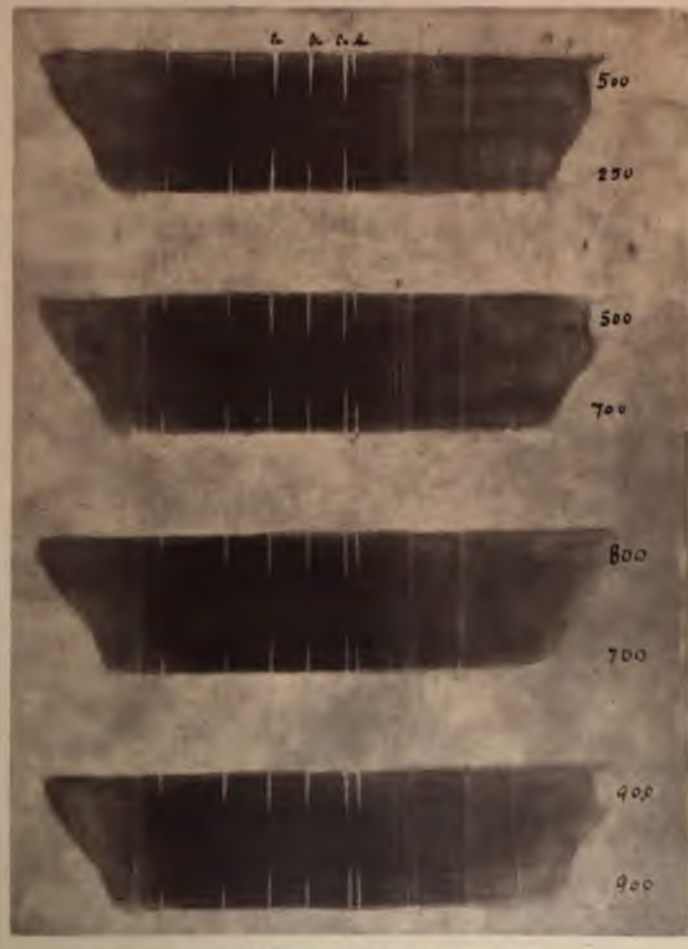
Donations for the library were received from the Holland Society at Harlem; R. Academy at Amsterdam; Geological Institute at Vienna; R. Academy at Turin; Revue Politique;

28. Hostler's.
29. Pennsylvania.
30. Old Seat of H. Fur:
31 Huntingdon Furn:
30 Dorsey Ore Banks

Proc. Am. Phil. Soc. Vol. XIV.

Woodburytype, A. P. R. P. Co., Phila.

Woodburytype, A. P. B. P. Co., Phila.



Woodburytype, A. P. S. P. Co., Phila.

Dr Joseph Leidy
1302 Filbert

PROCEEDINGS.

OF THE

AMERICAN PHILOSOPHICAL SOCIETY.

HELD AT PHILADELPHIA FOR PROMOTING USEFUL KNOWLEDGE.

VOL. XIV. JUNE TO DECEMBER, 1874. No. 93.

CONTENTS.

PAGE.

Stated Meeting, June 19, 1874 177
Stated Meeting, July 17, 1874 179
Stated Meeting, August 21, 1875 180
Stated Meeting, September 18, 1874 181
Stated Meeting, October 2, 1874 183
Stated Meeting, October 16, 1874 184
Stated Meeting, November 6, 1874 186
Stated Meeting, November 20, 1874 187
Stated Meeting, December 4, 1874 190

Description of Laboratory apparatus, by J. B. Britton 188
Jupiter-Cyclical Rainfall, by Pliny Earle Chase 193
Cyclical Rainfall at Barbadoes, by Pliny Earle Chase 195
Rainfall at "Husbands," Barbadoes, by Governor Rawson 203
Reply to Dr. T. Sterry Hunt, by F. A. Genth 216
On an improvement of the Burette Valve, by Geo. A. Koenig, 218
On American Tellurium and Bismuth minerals, by F. A. Genth 223
On the Resources, Productions and Social Condition of Egypt, by Alexander Delmar 232
List of the North American Platypterices, &c., with notes, by Aug. R. Grote 256
Results of an Examination of an Exploded Locomotive Boiler, and of Experiments to ascertain the Causes of Explosion, by Dr. Charles M. Cresson 264
Obituary Notice of Chief Justice John Meredith Read, by Eli K. Price 271
On the Alleged Parallelism of Coal Beds, by John J. Stevenson 283
On Exfoliation of Rocks near Gettysburg, by P. Frazer, Jr. 295
Pah-Ute Cremation 297
Letter of John C. Cresson, explaining the purchase of Oaks for the Michaux Grove 300
Stated Meeting, December 18, 1874 298

Map of the Schuylkill Water Gap, by Henry Martin Chance; see Minutes, page 183. The description will be published in the next number.

London Nature; and Society of Antiquaries; State Board of Health, Mass.; American Journal S. and A., New Haven; American Journal of Pharmacy; Medical News and Library; Penn Monthly; Board of Com. of Pub. Charities, Harrisburg; and Mr. J. E. Nourse, Washington.

Mr. Whitman reported progress for the Committee charged with estimating the cost of publishing Dr. Allen's paper.

On motion, the committee was continued.

Prof. Chase read a note on Cosmical Evolution.

Mr. W. E. Dubois communicated through the Secretary the results of an extended examination recently made in and for the Assay Department of the Mint at Philadelphia, of the practicability of assaying metals used in coinage by the spectrum apparatus. The paper was read and the drawings of the apparatus and spectra exhibited, and on motion, it was referred to the Secretaries, with power to publish the same with proper illustrations.

Mr. J W. Harden exhibited a model of a part of Big Sewell Mountain, Fayette Co., West Virginia, showing the number and position of the coal beds and limestones beds on the lands of the Langdale Coal and Iron Co., on the Kanawha River and Chesapeake and Ohio R. R. In the absence of Mr. Harden on account of illness, the Secretary explained the model and associated maps and sections, giving a description of the general geology of the lower coal measures in Virginia.

Pending nominations Nos. 753, 754, 755, 756 were read.

And the meeting was adjourned.

Stated Meeting, June 19th, 1874.

Present, 9 members.

Dr. Ruschenberger, in the chair.

Photographs for the Album were received, of Mr. F. Rogers, and of Senator Sumner.

A letter was received announcing the removal of the Société des Sciences Naturelles from Strasbourg to Nancy.

A letter was received from M. T. Leorgre, informing the Society of his election to succeed M. Quetelet, as Secretary of the Royal Belgian Academy.

Letters of acknowledgment were received from the N. H. S. at Zurich, (87), Aug. 20, 1873; the Royal Society at Edinburgh, (89), Dec., 1873; the Victoria Institute, London, June 5, (Proc. 13 Vols. and 1 part); and Smithsonian Institution. (XV, i.)

Letters of envoy were received from the Central Physical Observatory at St. Petersburg, April, 1874; Natural History Society, Zurich, Aug. 20, 1873; Victoria Institute, London, June 5, 1874; Department of State, U. S., Washington, May 23, 1874; and Coast Survey Office, Washington, May, 1874.

Donations for the Library were received from Mr. B. S. Lyman, Chief Geologist of Japan; Royal Prussian Academy, and Horticultural Society at Berlin; Natural History Society, Zurich; Société des Sciences, Nancy (Strasbourg); Flora Batava at Leyden; Royal Academy, Brussels; M. L. G. DeKoninck; Holland Society of Sciences, Harlem; Geographical Society, Anthropological Society, and Revue Politique, at Paris; Royal Observatory, and Royal Academy of Science, at Turin; Royal Institution, Royal Geographical Society, Royal Astronomical Society, and London Nature; Mr. Alex. J. Ellis, F.R.S.; Royal Society, Edinburgh; Essex Institute, Salem; American Academy of Arts and Sciences, and Natural History Society, Boston; Museum of Comparative Zoology, Cambridge; Anderson School of Natural History, Penekese; Rhode Island Society for the Encouragement of Domestic Industry, Providence; American Journal of Science and Arts, Prof. Jas. Hall, Academy of Natural Sciences, Historical Society, Franklin Institute, Journal of Pharmacy, Penn Monthly, American Chemist, Medical News and Library, Woman's Medical College, Water Department, Mr. E. D. Cope, Mr. H. C. Carey, and Mr. Isaac Lea, Philadelphia; Mr. T. J. Bingham, Harrisburg; Com-

mission for attending to Observations on the Transit of Venus; Engineer and War Departments, Washington.

The Committee to which was referred the cost of publishing the illustrations to Dr. Allen's Memoir, reported that it would cost $400. On motion an appropriation of $400 was ordered for that purpose.

Prof. Chase communicated two brief notes entitled—

1. On Rainfall in cyclonic years of Jupiter, at Greenwich, Philadelphia, Lisbon, San Francisco and Barbadoes.

2. On the Lunar Cyclical Rainfall at Barbadoes, for 27 years.

Pending nominations Nos. 753, 754, 755, 756 were read, and the Society was adjourned.

Stated Meeting, July 17th, 1874.

Present, 8 members.

Vice-President, FREDERICK FRALEY, in the Chair.

A letter from Dr. DaCosta, requesting the completion of his set of the Proceedings was read, and referred to the Committee on Publication, with power to take order.

Donations for the Library were received from the Royal Society of Tasmania; the Imperial Russian Academy, the Central Physical Observatory, the Natural History Society, at Riga; the Imperial Academy, Geological Institute, and Zoologico-Botanical Society, at Vienna; the Imperial Academy, German Geological Society, and Physical Society, at Berlin; the Societies at Bremen, Frankfort and Offenbach, the Hague, Lausanne and Bordeaux; the Musée Teyler; the Royal Academy, at Bruxell; the Academy of Medicine, Ecole des Mines, National Society of Antiquaries, and Revue Politique, at Paris; Mr. H. S. Munroe, of Yeddo; the Geographical Society of Mexico; the Royal Astronomical Society, Meteorological Committee, and Nature, in London; the Victoria Institute; the Philosophical and Literary So-

ciety, at Leeds; Boston Society of Natural History; Yale College, Peabody Museum, Silliman's Journal; the New Jersey Historical Society; the Penn Monthly, American Chemist, Journal of Pharmacy, and Franklin Institute, in Philadelphia; Peabody Institute, in Baltimore; War Department, Washington, and the Buffalo Society of Natural Sciences.

The death of Dr. Gouverneur Emerson, July 2, aged 78 was announced by Dr. Ruschenberger.

Dr. Genth read a communication in answer to criticisms by Dr. Hunt upon his paper upon Corundum, published in the Proceedings of the Society.

Dr. Charles M. Cresson communicated the results of an examination of an exploded locomotive boiler, with detailed accounts of experiments in reference to the causes of explosion.

Prof. Fraser communicated a note on certain formulæ of minerals, with reference to the question whether separate chemical compounds can co-exist in the same crystallized mineral.

Pending nominations, Nos. 753, 754, 755, 756, 757, 758 were read, and Nos. 753, 754 and 756 balloted for, and the following named persons were declared by the presiding officer duly elected members of the Society, viz.:

Sir Wm. George Armstrong, of Newcastle-on-Tyne.

Mr. Franklin Platt, of Philadelphia.

Mr. Henry Woodward, F.G.S., of London.

And the meeting was adjourned.

Stated Meeting, August 21st, 1874.

Present, 3 members.

Vice-President, Mr. Fraley, in the chair.

Dr. Genth presented a paper for publication in the Proceedings, entitled:—"Contributions from the Laboratory of

the University of Pennsylvania, No. 2. On an improvement of the Burette Valve." By Geo. A. König, Ph.D.

Dr. Genth communicated a paper entitled:—"Contributions from the Laboratory of the University of Pennsylvania, No. 3. On American Tellurium and Bismuth Minerals. By F. A. Genth."

And the meeting was adjourned.

Stated Meeting, September 18*th*, 1874.

Present, 8 members.

Vice-President, Mr. Fraley, in the chair.

A letter accepting membership was received from Mr. J. Norman Lockyer, dated 5 Alexandra Road Fenchly Road, London, June 25, 1874.

A letter accepting membership was received from Mr. Franklin Platt, dated 139 South Fifth street, Philadelphia, Sept. 8, 1874.

Letters acknowledging donations and exchanges were received from R. Academy, Lisbon, Aug. 3, 1774, (XII, ii, iii, XIII, ii, 67, 73, 74, 75, Catalogue II); the Society at Riga, Oct. 31, 1873, (XIV, iii, Proc. XII, 1, 2); the Imp. Academy at Vienna, Dec. 1, 1873, (88, 89); the Zoologico-Botanical Society, at Vienna, Jan., 1874, (Proc. XII, up to 89); the Royal Pontifical Academy d. N. L., at Rome, Dec. 9, 1873, (88, 89); the British Association, London, June 12, 1874, (XVI, 90, 91); the Royal Observatory, at Greenwich, July 21, 1874, (90, 91); the Royal Society, London, June 25, 1874, (III; XIV, ii, XV, i, 62, 88, 89, 90, 91); the Meteorological Office of the R. S., London, June, 10, 1874, (90, 91); the Zoological Society, London, July 3, 1874, (XV, i, 89, 90, 91); the Society of Antiquaries, Somerset House, London, June 25, 1874, (XV, i, 90, 91); the Statistical Society, 12 St. James Square, London, June 17, 1784, (XV, i, 90, 91); the Ratcliffe Observatory, Oxford, June 19, 1874, (XV, i, 90, 91); the Literary and Philosophical Society, R.

Inst., Liverpool, Dec. 31, 1873, (O.S. I to VI, N. S., I to XIII); the Literary and Philosophical, Leeds, June 8, 1874, (XV, i, 88, 91).

Letters of envoy were received from the Physical Society, Berlin, April 15, 1874; the Imperial Academy, Vienna, Feb. 23, 1874; the Zoologico-Botanical Society, Vienna, Jan. 7, 1874; Royal Hungarian Academy, Pesth, Nov. 10, 1873; Holland Society, Harlem, Dec., 1873; Society of Emulation, Abbeville, June 1, 1874; Teyler Museum, Meteorological Office, London, June 23, 1874; Literary and Philosophical Soc. Manchester, June, 1874; Literary and Philosophical Soc. Liverpool, Dec. 29, 1873; National Academy, B. Aires, May, 10, 1874; Museum, B Aires, April 20, 1874; Metropolitan Museum of Arts, New York, Sept. 16, 1874.

A letter was received from Mr. Alex. Agassiz, respecting his father's European Publications, to be distributed, dated July 22, 1874.

A letter was received from Mr. Geo Travers, dated Newstadt, A. H., July 4, 1874, offering for sale the Shai-n-Sinsin papyrus, price £120 sterling.

Donations for the Library were reported from the R. and Imp. Academies at Berlin and Brussels; the Societies at Riga, Görlitz, Leeds, Glasgow, and Salem, Mass; the Observatories at Prague, San Fernando, and Oxford; the Geological Bureau, at Stockholm; the City of Pesth; the S. d N. L, at Rome; the Geographical Society, American Society for the encouragement of National Industry, Museum of Natural History, School of Mines, Weekly Gazette of Medicine, Revue Politique, and Chev. Leopold Hugo, of Paris; the Royal, Chemical, Asiatic, Astronomical, Zoological, and Antiquarian Societies, Victoria Institute, Cobden Club, Meteorological Committee, and Nature, of London; the Geological Museum, at Montreal; the American Antiquarian Society; Silliman's Journal; Dr. Jarvis of Dorchester; Prof. Roehrig, of Ithaca; the Naturaliste Canadien, of Quebec; the American Chemist, New York; the Metropolitan Museum, of New York; the Franklin Institute, Penn

Monthly, and Dr. R. J. Levis, of Philadelphia; Prof. S. S. Haldeman, and the University of Missouri.

The death of Dr. Jeffries Wyman, of Cambridge, Sept. 4, aged 60, was announced by Dr. LeConte.

Mr. Eli K. Price, as Chairman of Committee on Nursery, &c., communicated "A list of Oaks imported by the Fairmount Park Commission, in 1874, for the Michaux Grove, being the selection of John C. Cresson, Esq., when last in Europe, showing which of them are living."

Mr. Lesley described an upthrow fault recently discovered by Mr. Chance, volunteer assistant of the Second Geological Survey of Pennsylvania, crossing the Schuylkill river in the gap of the Kittatinny Mountain, below Port Clinton.

Pending nominations, Nos. 755, 757, 758, and new nominations, 759, 760, 761, 762, 763, were read.

And the meeting was adjourned.

Stated Meeting, October 2d, 1874.

Present, 11 members.

Secretary, Dr. LeConte, in the Chair.

Photographs for the Album were received from Mr. Thos. Meehan, and Prof. Stephen Alexander.

A letter from the Rantoul Literary Society, dated Rantoul, Champaign County, Ill., Sept. 28th, 1874, requesting the publications of the Society, was read, and on motion, the Society was ordered to be placed on the list to receive the Proceedings.

A letter from the Ohio State Librarian, dated Columbus, O. Sept. 22, 1874, requesting a copy of the Catalogue of the Library was read, and on motion, the request was granted.

A letter from Dr. Fredk. Krauss, on behalf of the Verein für Vaterländ. Naturkunde in Würtemberg, dated Stuttgart, Aug. 10, 1874, asking for the completion of their set of Proc. A. P. S., and a complete set of Transactions A. P. S., and promising to complete the set of V. f. V. N. in W.

Jahrgänge (30 years in 3 parts) for the A. P. S., Library, was read, and on motion, the request was granted.

Letters of acknowledgement were received from the R. Academy, Copenhagen, (XV, i, 90, 91); K. K. C. Anstalt für Meteorologie und Erdmagnetismus, Vienna, (90); Prof. Hochstetter, (89); Dr. Jos. Hyrtl, (88, 89); Linnean Society, London, (XIV, ii, XV, i, 88 +); New York Historical Society, (92).

Letters of envoy were received from the Linnean Society, and N. Y. State Library.

Donations for the Library were received from the Editor's of Revue Politique, Paris; Nature, Royal Society, and Linnean Society, London; Prof. Silliman and Dana, N. Haven, N. Y. State Library, Regents of the University, Buffalo Society of Nat. Sciences, Penn. R. R., U. S. Naval Observatory, and National Educational Association.

The death of M. Elie de Beaumont, at Paris, Sept. 24, 1874, aged 75, was announced by Dr. Genth.

Mr. Delmar, late director of the U. S. Bureau of Statistics, read a communication on the resources, productions, and social condition of Egypt.

Pending nominations, 755, 757 to 763, were read.

And the meeting was adjourned.

Stated Meeting, October 16th, 1874.

Present, 12 members.

Vice-President, Mr. Fraley, in the chair.

A letter accepting membership was received from Mr. Henry Woodward, F.R.S., dated British Museum, London, Oct. 3. 1874.

A letter was read from Mr. Jared P. Kirtland, dated East Rockport P. O., Cayahoga County, Ohio, Oct. 1, 1874.

Letters from B. Westermann & Co. and E. Steiger, Booksellers, and on motion made, it was resolved to instruct the Secretaries not to sell single numbers of the Proceedings,

lest the stock of Proceedings be so diminished as to make it impossible to supply corresponding Societies.

The request of the Leeds Philosophical and Literary Society for Nos, 75 and 79, to complete their set, was on motion, granted.

Letters of acknowledgment were received from the Society at Riga, Feb. 28, 1874, (90, 91); Boston Public Library, Oct. 12, 1874, (XIV, 92); and War Department, Washington, Oct. 5, 1874, (92).

Letters of envoy were received from the Swedish Geological Bureau, Stockholm, Nov. 15, 1873; and the Prussian Academy, Dec., 1873.

Donations for the Library were received from the Academies at Berlin and Brussels, and Salem, Mass.; the Society at Zwickau; the Paris Geographical Society, and Revue Politique; London Nature; Boston Natural History Society; Journal of Medical Sciences, Journal of Pharmacy, Medical News and Library, Mr. H. C. Carey, and the Hon. B. H. Brewster, of Philadelphia.

Mr. Lesley described the marked change in the aspect of the northern and northwestern counties in the State during the last thirty years, and the progress of the Geological Survey of that region; the facilities afforded for it, and the private collections of fossils in it, at Mansfield, Warren and Titusville; the discovery of the Devonian (No. IX) fish-beds at various places from the Hudson to the Alleghany rivers; the differentiation of the Conglomerate from the oil region sand rocks, and of the Marshall group from the Chemung, &c.

Pending nominations, 755, 757 to 763, and new nomination No. 764, were read.

Nominations 755 to 763 were balloted for, and after scrutiny of the ballot boxes by the presiding officers, the following were declared duly elected members of the Society:

Rev. James Freeman Clarke, of Boston.

Franz Ritter von Hauer, of Vienna.

Rawson W. Rawson, Governor of Barbadoes.

Prof. S. P. Sadtler, of Philadelphia.
Prof. G. A. König, of Philadelphia.
Prof. C. F. Himes, of Carlisle.
Dr. R. S. Kenderdine, of Philadelphia.
Mr. A. R. C. Selwyn, of Montreal.
And the meeting was adjourned.

Stated Meeting, November 6th, 1874.

Present, 16 members.

Secretary, Dr. LeConte, in the chair.

Letters accepting membership were received from Prof. Samuel P. Sadtler, dated Philadelphia, Oct. 19; from Prof. George A. König, dated Philadelphia, Oct. 19; from the Rev. James Freeman Clarke, dated Jamaica Plains, near Boston, Mass., Oct. 20; and from Prof. Charles F. Himes, dated Carsisle, Pa., Nov. 4, 1874.

A letter was received from the relatives of M. F. P. G. Guizot, dated Val Richer, Sept. 13, announcing his death on the preceding day, Sept. 12, at the age of 86.

Letters of acknowledgment in receipt of Proceedings A. P. S., were read from the Observatory at Munich, Aug. 7, (Nos. 90, 91); Astronomical Society, at Leipsig, July 20, (90, 91); Royal Society, at Göttingen, July 6, (XV, i, 90, 91); Lyceum of Natural History, N. Y., Oct. 12, (92); and University of Toronto, Oct. 19, (84, 92. Wants 86 to 91.

Donations for the Library were announced from the Asiatic Society of Japan; the Swedish Statistical Bureau and Geological Survey; the Danish Archæological Society; the Academies at Berlin and Copenhagen; the German Geological Society; the Imperial Institute at Vienna; the Academy at Dijon; the Geographical and Anthropological Societies, and Revue Politique, at Paris; the Victoria Institute, Royal Geographical Society, and Nature, at London; the Geological Society of Glasgow; the Geological Survey of Canada; Essex Institute; Yale College; Silliman's Journal;

Franklin Institute; Penn Monthly; Gen. W. A. Stokes; Smithsonian Institution; Bureau of U. S. Engineers; Dr. Hayden; Mr. Outenbridge; the Medical News; and the Buffalo Society of Natural Sciences.

The death of Prof. Samuel J. Gummere, President of Haverford College, at Haverford, Oct. 22, aged 63, was announced, and Prof. Thos. Chase, was on motion, appointed to prepare an obituary notice of the deceased.

Mr. Britton exhibited to the members present large specimen pieces of coals sent for metallurgical analysis from the Luray Mine, Carbon Mine, and mines near Rocky Spring Station on the Union Pacific Railroad, 830 miles west of Omaha. The character, age, and relationships of these coals with the so-called Lignitic beds of Hayden, the Denver and Raton and Santa Fe coals, were discussed at length by Dr. Genth and Dr. LeConte.

Pending nomination, No. 764 was read, and the meeting was adjourned.

Stated Meeting, November 20th, 1874.

Present, 17 members.

Vice-President, Mr. Fraley, in the chair.

A Photograph for the Album was received from Prof. Traill Green, of Lafayette College, Easton, Pa.

A letter respecting the cataloguing of Libraries was received from Mr. W. C. Flagg, Secretary Ill. S. Farmer's Association, dated Moro, Ill., Nov. 10, 1874.

A blank to be filled was received from the Secretary of the Bureau of Education, at Washington, dated Nov. 11, 1874.

Letters acknowledging the receipt of the Society's Publications, were received from the Hungarian Academy of Sciences, Oct. 17, (XV, i, 88, 89, 90, 91); the R. Bavarian Academy, Sept. 15, (XV, i, 90, 91); the Philosophical and Literary Society, at Leeds, Oct. 28, (75 and 79); Prof. C. E. Anthon, New York, Nov. 18, (81 to 92); Prof. Traill Green,

Easton, Pa., Nov. 12, (81 to 92); Dr. Robert Peter, Lexington, Ky., Nov. 9, (81 to 92); and the Ohio State Library, Columbus, Nov. 13 (Cat. Pt. I).

Letters of envoy were received from the R. Bavarian Academy, Munich, Sept. 13, Mr. Stan. Meunier, Professor of Comparative Geology in Natural History Museum, at Paris, Oct. 28; the Meteorological Office of the Royal Society, in London; and the Smithsonian Institution.

Donations for the Library were received from the German Geological Society, the R. Prussian Academy, the Geological Association, at Dresden; the Vaudoise Society, at Lausanne, the Batavian Society Ex. Phil., at Rotterdam, the Revue Politique, M. Stan. Meunier, the R. Astronomical Society, London Nature, Boston Public Library, Academy of Natural Sciences, Franklin Institute, American Journal of Pharmacy, U. S. Coast Survey, Department of the Interior, and Mr. Adolph Schmidt, Jefferson City.

The volume on Comparative Geology presented by M. Meunier, was on motion, referred to a committee to be appointed at the next meeting.

The death of Mr. Charles B. Trego, Treasurer of the Society, at Philadelphia, Nov. 10, aged 80 years, was announced by the Vice-President, and on motion, Mr. S. W. Roberts was appointed to prepare an obituary notice of the deceased.

Mr. Britton exhibited and explained a model illustrating his method of keeping a laboratory free from the gases evolved when metals and minerals are dissolved in acids.

He dissolves in test tubes supported in position on wire gauze frames. The tops of the tubes are covered with glasses shaped like tubular funnels inverted, the tubular end of which being bent at nearly a right angle are made to pass horizontally into a long wooden chamber four inches wide by six inches deep. The chamber may be of any length; it connects at either end or in the centre with a wooden chimney, six by twelve inches in the clear, passing from the laboratory up and above the roof of the building. Heat is applied to the lower end of the tubes by moveable Bunsen burners. The gasses are carried away as fast as evolved by the constant current of air which passes through the chamber and up the chimney.

So completely have the gasses been conducted away, that several very delicate Becker balances have been in use for some years within a few feet of the tubes, without being perceptibly affected. He uses tubes va-

rying from one to two inches in diameter and about ten inches long—and also flasks. Any number may be used at the same time, set about six inches apart. He has frames for thirty-six. It is best to make the funnels pear-shaped, to allow their edges to slip into the tubes that any drops of condensed moisture may not fall outside.

Mr. Britton also exhibited several mounted burettes for volumetric analysis of the kind described in the Journal of the Franklin Institute, for May 1870, and which he has had in use for more than nine years. He exhibited them to show that the one exhibited by Dr. Geo. A. Koenig, at the meeting of the Society, held August 21st, 1874, differed in no essential feature from them.

Mr. Britton had tried wood, leather, lead, tin, glass, india-rubber and cork, for the stopper or valve. He preferred close-grained cork when using solutions of per mangenate and bichromate of potash, and this after five thousand iron determinations with it. Glass he preferred to all other substances when using acids or strong alkaline solutions.

The graduation was on white paper behind the tube. The thumb knob of the screw was behind the frame, but the spring and valve was in front. This arrangement he preferred. The contents of the tube could be discharged much faster than necessary for analytical purposes, or so slow that only a fraction of a drop could be caught on the stirring rod and conveyed to the solution to be tested in the vessel beneath.

He also exhibited an adjustment of the spring and screw to the rod-stoppered burette. The burette was mounted on a stand. A spring lever was on the top and connected at one end with the rod-stopper, and at the other end with a metal rod. The latter extended down the back of the instrument to near the bottom, and had attached to it a thumb-screw arrangement. By simply turning the screw the stopper could be completely controlled while the eye watched the flow.

Mr. Britton referred again to the Rocky Mountain coals exhibited at the last meeting, simply saying in advance of analysis that they were all coking coals.

Mr. Poole obliged the members present with descriptions of the coals of Nova Scotia, and of the character of the gold quartz, veins, and present condition of the gold-mining industry of the province.

Dr. LeConte offered for publication in the Proceedings, a list of North American Iepidopteræ (platypterices, &c.,) with notes by Augustus R. Grote, of Albany.

Minutes of the last meeting of Officers and Members in Council, were read.

Pending nominations, No. 764, was read.

Mr. Fraley nominated in behalf of the Committee of Finance, Mr. J. Sergeant Price, to fill the vacancy left by the

death of the Treasurer. On motion, Mr. Price was elected to fill the vacancy.

Mr. Fraley reported that he had received and was prepared to turn over to the Treasurer elected, the quarterly interest on the Michaux Legacy, due Oct. 1. 1874.

And the meeting was adjourned.

Stated Meeting, December 4th, 1874.

Present, 17 members.

Vice-President, MR. FRALEY, in the chair.

A letter accepting membership was received from Baron Franz von Hauer, dated Nov. 7, 1874.

A letter requesting additional copies of Proceedings and Transactions, was received from the Holland Society of Science, at Harlem, Nov. 3, 1874.

Letters of envoy were received from the Entomological Society, of Belgium, and the State Department, at Washington.

A letter was received from the Baron de la Roncière le Noury, V. A. President of the Geological Society at Paris, with documents, asking for the concurrence of the A. P. S., in the International Congress of Geographical Sciences to be held next spring, in Paris.

Donations for the Library were received from the Editor of Flora Batava, Leyden; the Entomological Society, Belgium; Annales des Mines; Revue Politique; London Nature; Geological Society, and Society of Antiquaries, London; American Chemist; Prof. James Hall, and the Regents of the University of New York; Silliman's Journal, Franklin Institute, Penn Monthly, Mrs. Emma Seiler, of Philadelphia; and Dr. T. Sterry Hunt, of Boston.

The death of John Meredith Read, Ex-Chief Justice of the Supreme Court of Pennsylvania, at Philadelphia, Nov. 29, aged 77, was announced by Mr. E. K. Price, who, on motion, was appointed to prepare an obituary notice of the deceased.

Prof. G. Guyot, of Princeton, N. J., Prof. Cook, of New Brunswick, N. J., and Prof. Lesley, were appointed the committee to report on M. Meunier's book, received at the last meeting.

Mr. Britton reported analyses of Rocky Mountain coals, and exhibited the cokes obtained from them.

Dr. Cresson reported on their gas producing and heat producing qualities.

Mr. Goodfellow said that before the next meeting news would be received of a rare event, for which astromomers had been waiting and preparing for a century. Next Tuesday the Transit of Venus would again occur, the times of which as calculated for Washington he gave. So extensive and costly are the preparations for observing this event in distant parts of the world made by various Governments, that it becomes evident the time has arrived when public sentiment is alive to the value, and government action is ready to supply the needs of accurate science, for the benefit of society at large.

Mr. Goodfellow then gave a sketch of the history of the Observation of the Transit of 1769, and showed, from Dr. Smith's memoir in the Transactions of the American Philosophical Society, that Dr. Smith's calculations of the sun's parallax, while they widely differ from the results of Encke, approximated much nearer to the truth.

Dr. König explained again by diagrams, the essential points of difference between Mr. Britton's burette, the high value of which he acknowledged, and his own published improvement upon it. Mr. Brinton insisted that they were essentially the same. Mr. Fraley said that the decision of such a question must be left to the practice of Chemists.

Dr. W. I. Hoffman's letter to Dr J. L. LeConte on the practice of Cremation by the Pàh-Ute Indians, of Eastern California, was then read by the Secretary, and Dr. Horn confirmed Dr. Hoffman's statements, adding that the practice was common to all branches of the Pàh-Ute Tribe.

Mrs. Seiler's recently published investigations on the voice in speech were then described by the Secretary, and the

two capital points which the learned authoress considers to be new discoveries were pointed out, namely, the fixed pitch of the consonant, and the duplex instrumentation of the voice; the mouth and the "vocal organs" commonly so-called, being two entirely different and independent instruments acting in harmony, but the mouth being entirely capable of speech after the destruction of the larynx and cords.

Prof. Frazer described by diagrams the phenomenon of exfoliation in the syenite-like rocks of Gettysburg. A discussion ensued in which Dr. König expressed his dissent from Naumann's views respecting the cause of granitic exfoliation being the sun's heat. Dr. Genth also called attention to the fact that southern boulders were evidently not produced in the same way as northern boulders.

The report of the late Treasurer of the Society as made out by his administrator, was read by the Treasurer, Mr. Price, and regularly referred for examination to the Finance Committee.

Pending nomination, No. 764 was read.

On motion of Mr. E. K. Price. it was

Resolved, That the Treasurer be directed to pay one half the income received and to be received from the Michaux Legacy, to the Treasurer of the Fairmount Park Commissioners, for the Michaux Grove, &c, agreeably to arrangement of March 18, 1870.

The appointment of a Standing Committee of Botanists on the purchase of trees for the Michaux Grove, in Fairmount Park, was moved by Mr. Price, and laid over by the rules, to the next meeting.

The Curators, on motion, were authorized to permit Mr. Herbert Welsh to copy the portrait of Washington, in possession of the Society, under such regulations for its safety as the Curators may provide.

And the meeting was adjourned.

JUPITER-CYCLICAL RAINFALL.

By Pliny Earle Chase, Professor of Physics in Haverford College.

(*Read before the American Philosophical Society, June 19th*, 1874.)

The records of daily rainfall for twenty-seven years, at "Husband's" Station, Barbadoes, for which I am indebted to the courtesy of His Excellency Governor Rawson W. Rawson, C. B., have enabled me to extend my cyclical researches, and to discover some new and interesting features in the cosmical disturbances of local meteorology.

Although my previous investigations have convinced me that each of the planets exerts, on our atmospheric currents, an appreciable influence, which might be usefully formulated for any given station, provided the observations were enough extended, I have thought it best to confine myself mostly to the study of such weather modifications as are dependent upon Jupiter and the moon.

Those who are accustomed to think of simple tidal disturbances as the only ones to which we can reasonably look for planetary influence, and even those who are also willing to attach some importance to the modification of atmospheric elasticity by direct attraction, are doubtless prepared to believe, on sufficient evidence, that the moon may affect our winds and storms to a slight degree, while they are extremely skeptical,

TABLE I.

Normal Percentages of Rainfall at Barbadoes in Jovian Synodic Years.

	1847–55.	1855–63.	1863–72.	1847–58.	1859–72.	1847–72.
1	124	132	82	111	110	112
2	110	151	88	107	125	116
3	102	156	93	101	131	116
4	98	151	89	94	131	112
5	102	137	78	91	119	105
6	107	124	70	99	102	100
7	106	121	73	108	91	100
8	95	122	87	110	91	101
9	75	121	102	101	95	98
10	62	120	109	94	92	96
11	67	123	119	101	102	101
12	77	117	132	107	109	108
13	86	95	139	105	107	106
14	99	75	139	102	104	103
15	100	70	137	101	104	103
16	99	69	129	99	100	99
17	92	65	124	94	94	94
18	83	64	123	88	92	90
19	74	69	114	81	90	86
20	68	75	100	74	87	81
21	68	77	90	72	84	78
22	82	76	84	80	81	80
23	109	82	84	97	87	92
24	135	90	89	113	98	106
25	141	84	97	116	100	108
26	126	76	99	105	98	102
27	114	82	94	96	99	98
28	122	85	82	102	96	99
29	142	88	78	120	87	103
30	142	104	76	126	91	108

the disturbing elements, I should have been compelled to consider the evidences of lunar influence on the weather quite as questionable as those of discoverable planetary influence.

My predictions of increasing range and regularity of disturbance, in approaching the equator, had been confirmed by comparisons of observations in Great Britain, Canada, New England, Philadelphia, Lisbon and San Francisco. Their apparent failure in an island which seemed, on many accounts, so favorably situated for their verification, cast a shadow of doubt on my previous conclusions, and I was even inclined to ask if it could be possible that the many coincidences which I had taken as indicative of law, were merely accidental.

This skepticism, however, was soon removed. The cumulative action of the aerial tidal-waves in blending different currents, of which I have so often spoken, may be easily obscured, if it is not wholly overborne, by insular influences, by the violent hurricanes to which the Windward Islands are subject, and even by the occasional intrusion of the south-easterly trade-winds. Where there is a liability to sudden heavy rains, any one of which would suffice to make important changes in a curve

TABLE I.

Normal Percentages of Rainfall at "Husband's," in Thirtieths of a Solar Year, and on Lunar Days at Different Epochs.

	Solar.				Lunar.						
	1847–'53.	1856–'64.	1865–'73.	1847–'73.	S. Sol.	W. Sol.	Ver. Eq.	Aut. Eq	V. and A. Equinox.	S. and W. Solstice.	Year.
1	64	62	82	69	92	82	122	95	101	73	93
2	55	51	75	60	98	83	104	100	104	83	96
3	50	49	62	53	100	90	94	110	116	92	103
4	45	54	52	50	99	95	94	113	119	95	104
5	38	53	41	44	98	98	103	107	114	96	104
6	33	41	29	34	100	105	110	104	109	103	104
7	34	30	23	29	107	118	105	109	104	111	109
8	34	33	23	30	115	130	94	123	106	114	116
9	37	44	25	35	119	135	88	133	113	117	121
10	48	50	31	43	117	136	89	136	124	122	125
11	65	53	45	55	115	135	95	126	121	131	123
12	82	63	60	69	117	127	104	111	107	133	116
13	92	82	76	84	115	109	104	101	101	126	108
14	94	95	101	96	115	90	98	98	104	121	105
15	98	96	130	107	118	78	90	93	99	121	100
16	107	101	140	115	108	75	82	82	83	111	90
17	118	115	129	120	88	79	80	70	70	97	79
18	132	132	122	129	79	89	66	66	67	96	77
19	140	144	139	141	82	101	88	74	72	102	84
20	137	146	163	148	83	106	86	85	82	96	89
21	141	145	170	152	78	97	81	91	92	86	88
22	154	147	165	155	77	83	77	89	93	80	85
23	160	154	166	160	83	80	83	84	83	78	82
24	164	174	183	173	92	89	97	86	76	79	86
25	181	197	190	189	97	100	107	93	81	82	93
26	196	204	167	190	100	104	103	102	94	92	99
27	181	182	131	166	105	101	105	107	110	105	106
28	140	136	106	123	108	100	130	109	120	102	110
29	103	94	92	96	101	97	154	106	122	84	107
30	79	74	85	79	92	89	147	99	112	71	98

representing the mean of several years' observations, it is not strange that great care should be needful in order to determine the approximate character of the normal flexures.

My previous discussions having shown that the lunar rain-curves at a given station vary somewhat at different seasons of the year, I first computed the normal curves at "Husband's" for each month of the year independently, and then "smoothed" the curves by taking the fourth successive means between the daily normals of successive months. This second series of normals, although insufficient for any conclusive inferences based on comparisons between consecutive months, should furnish approximate evidence of the normal changes, as well as means for making eighteen entirely independent comparisons between curves with intervals of five or six months. The normals for these two series of curves are given in Tables III. and IV. If there were no other than an accidental connection between the several curves, the chances of agreement or disagreement between the normal excesses or deficiencies of rainfall, in each independent comparison, would be equal, there being a probability of 15 days agreement and 15 days disagreement. The actual accordances and discordances and the ratios indicative of a *vera causa* in lunar action, are given below, 1 being the ratio of probable accidental agreement.

TABLE II.

Normal Proportions of Rainfall at "Husband's" on Lunar Days of each Calendar Month, for Independent Comparisons.

	Jan.	Feb.	Mar.	Apl.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1.....	29	31	10	49	66	51	49	121	121	112	76	41
2.....	32	32	11	30	60	58	54	132	136	120	67	50
3.....	34	31	17	15	58	64	60	129	143	157	73	58
4.....	33	29	25	9	58	76	64	110	144	164	95	48
5.....	34	34	30	11	57	85	73	91	137	148	112	33
6.....	38	41	27	16	56	78	94	83	120	148	119	31
7.....	42	39	18	19	58	68	107	99	108	154	134	42
8.....	47	31	12	18	60	70	102	126	114	161	156	48
9.....	56	26	9	15	62	77	95	138	130	170	166	45
10.....	61	29	10	16	59	88	93	125	161	181	162	43
11.....	58	38	13	21	49	114	89	107	154	158	153	44
12.....	49	42	21	29	41	134	85	104	123	134	142	43
13.....	38	36	28	30	39	119	89	113	96	135	114	47
14.....	32	27	34	23	41	85	106	127	93	148	77	59
15.....	30	22	32	16	45	64	124	134	93	143	53	64
16.....	31	24	22	15	44	57	119	115	83	117	56	53
17.....	34	27	14	16	45	55	94	81	71	98	69	42
18.....	40	28	15	18	49	63	72	62	61	99	77	47
19.....	44	28	15	23	46	75	63	73	64	105	91	55
20.....	41	31	12	30	36	75	62	84	79	114	111	46
21.....	35	31	11	35	26	68	69	80	93	126	114	29
22.....	33	28	12	38	22	61	73	85	90	129	100	20
23.....	36	29	10	36	31	55	71	102	72	121	88	20
24.....	41	31	12	24	57	54	67	109	65	117	97	23
25.....	38	31	17	12	77	57	66	103	85	119	117	31
26.....	34	32	21	12	68	67	74	103	105	133	120	40
27.....	33	35	20	32	46	77	85	120	106	156	102	49
28.....	32	39	19	58	50	69	81	136	98	170	92	55
29.....	28	39	19	68	71	52	63	127	96	165	91	53
30.....	27	35	14	63	76	45	50	115	104	142	88	44

		A.	D.	Ratio.			A.	D.	Ratio.
Jan.	June.....	24	6	4.00	July	Dec.	23	7	3.29
"	July	25	5	5.00	"	Jan.	25	5	5.00
"	Aug.....	20	10	2.00	"	Feb.	24	6	4.00
Sum.....		69	21	3.29	Sum.....		72	18	4.00
Feb.	July	24	6	4.00	Aug.	Jan.	20	10	2.00
"	Aug.....	23	7	3.29	"	Feb.....	23	7	3.29
"	Sep.	24	6	4.00	"	Mar.	18	12	1.50
Sum.....		71	19	3.74	Sum.....		61	29	2.10
Mar.	Aug.....	18	12	1.50	Sep.	Feb.	24	6	4.00
"	Sep.	21	9	2.33	"	Mar.	21	9	2.33
"	Oct.	20	10	2.00	"	Apl.	20	10	2.00
Sum.....		59	31	1.90	Sum.....		65	25	2.60
Apl.	Sep.	20	10	2.00	Oct.	Mar.	20	10	2.00
"	Oct.	17	13	1.31	"	Apl.	17	13	1.31
"	Nov.	19	11	1.73	"	May	24	6	4.00
Sum.....		56	34	1.65	Sum.....		61	29	2.10
May	Oct.	24	6	4.00	Nov.	Apl.	19	11	1.73
"	Nov.	25	5	5.00	"	May	25	5	5.00
"	Dec.	23	7	3.29	"	June.....	23	7	3.29
Sum.....		72	18	4.00	Sum.....		67	23	2.83
June	Nov.	23	7	3.29	Dec.	May	23	7	3.29
"	Dec.	23	7	3.29	"	June.....	23	7	3.29
"	Jan.	24	6	4.00	"	July	24	6	4.00
Sum.....		70	20	3.50	Sum.....		70	20	3.50

	A.	D.	Ratio.
Summer, Winter.....	22	8	2.75
Spring, Autumn.....	21	9	2.33
Vernal Equinox, Autumnal Equinox.....	18	12	1.50
Summer Solstice, Winter Solstice.....	23	7	3.29
Mean Annual.....	22	8	2.75

TABLE III.

Normal Percentages of Rainfall at "Husband's," on Lunar Days of each Calendar Month, for Independent Comparisons.

	Jan.	Feb.	Mar.	Apl.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
1.....	76	96	57	184	128	70	62	112	116	81	74	95
2.....	83	99	64	112	115	81	68	122	130	87	64	116
3.....	89	97	95	56	112	89	75	119	137	114	70	133
4.....	88	91	138	36	112	105	80	102	137	119	93	111
5.....	90	106	169	41	111	118	92	84	131	107	108	75
6.....	99	129	153	60	109	109	117	77	115	107	114	72
7.....	109	122	103	70	112	94	134	92	104	112	129	96
8.....	124	97	67	67	115	97	128	117	109	117	150	111
9.....	147	81	54	58	119	107	119	128	124	123	160	104
10.....	161	91	54	59	114	122	117	116	144	131	156	99
11.....	153	120	75	80	94	158	112	100	147	114	148	101
12.....	129	133	116	108	79	186	106	96	118	97	137	100
13.....	101	113	162	113	75	165	111	105	92	96	110	109
14.....	84	83	194	87	78	118	133	118	89	107	74	136
15.....	79	69	183	61	86	89	155	124	88	104	51	148
16.....	80	75	123	56	86	79	150	107	80	85	54	123
17.....	88	85	82	61	86	77	118	75	68	71	67	97
18.....	105	87	87	67	94	88	90	58	59	72	74	109
19.....	116	89	83	87	89	104	79	68	61	76	88	127
20.....	108	98	70	114	70	105	78	78	75	82	107	105
21.....	93	99	64	131	51	94	87	75	89	91	110	66
22.....	86	88	65	141	42	85	92	79	86	93	96	47
23.....	96	90	58	134	61	77	88	93	69	88	85	46
24.....	109	99	65	92	110	74	83	101	62	85	94	58
25.....	101	98	96	44	149	79	83	95	81	86	113	71
26.....	89	103	117	46	130	93	92	95	101	96	116	92
27.....	88	111	115	122	89	107	107	112	101	113	96	112
28.....	84	122	109	218	96	96	102	126	94	123	88	126
29	75	122	105	257	138	73	79	118	92	120	88	121
30.....	71	109	76	237	147	63	68	107	99	103	86	102

If these accordances can be properly interpreted as indicative of lunar influence, they represent results analogous to those we might look for from the simple means of observation extended over a period of about one hundred years. When the average daily temperature is most settled, near the Summer and Winter Solstices, the lunar curves seem most accordant, while they are most opposed when the changes of season and temperature are most rapid and in the most opposite directions, near the Vernal and Autumnal Equinoxes.

Having thus shown that the general agreement is too great to be regarded as merely accidental, and that there are valid reasons for important differences in the curves for different months, we are prepared for the sixty-six comparisons of entirely independent curves, for which Table III. furnishes the data. The sums of the agreements and disagreements between the curves for each month and for all the remaining months, are as follows:

	A.	D.		A.	D.		A.	D.
January,	173	157	May,	170	160	September,	198	132
February,	200	130	June,	198	132	October,	202	128
March,	190	140	July,	196	134	November,	188	142
April,	148	182	August,	180	150	December,	179	151

Here again we find convincing evidence, and in some respects more satisfactory than before, of a uniformity of lunar action that is obscured by the preponderating variations of solar action, only in the single month

TABLE IV.

Normal Percentages of Rainfall at "Husband's," on Lunar Days of each Calendar Month, for Independent Comparisons at Intervals of Five or Six Months.

	Jan.	Feb.	Mar.	Apl.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
1	84	90	111	126	102	86	86	98	99	90	81	81
2	91	91	94	102	97	89	95	109	108	94	83	85
3	99	95	87	89	93	92	98	113	117	110	98	96
4	97	96	91	91	97	97	98	109	118	115	106	100
5	94	104	105	99	104	104	99	101	109	111	104	96
6	101	114	113	101	104	107	102	99	103	108	106	100
7	111	110	102	97	102	108	109	105	106	112	116	115
8	118	101	86	91	102	111	116	116	116	122	129	130
9	122	98	79	89	105	113	119	124	128	132	136	136
10	127	107	83	90	109	117	120	125	132	138	138	136
11	130	120	99	98	117	125	120	118	124	128	129	131
12	123	125	116	110	125	132	120	108	106	111	116	120
13	109	116	119	112	118	125	118	105	104	100	103	107
14	99	105	111	102	102	114	120	113	102	97	94	97
15	94	95	98	91	93	110	123	117	102	90	85	88
16	87	86	84	88	87	103	115	106	91	80	75	81
17	86	85	79	77	83	90	90	81	73	70	74	79
18	97	94	85	84	88	86	77	67	65	69	77	88
19	108	100	89	90	93	90	80	70	69	76	87	101
20	104	99	93	89	89	88	83	79	80	87	95	103
21	89	91	92	85	81	83	83	83	87	93	109	93
22	77	83	90	83	76	80	84	85	87	99	88	81
23	79	86	90	86	79	80	85	85	82	82	80	77
24	88	92	91	94	91	87	86	85	81	82	83	84
25	94	93	91	99	102	94	88	87	88	91	95	96
26	97	95	94	97	102	99	96	96	98	102	104	102
27	101	105	110	106	102	104	107	108	107	107	105	103
28	104	114	136	135	113	104	108	111	110	109	105	103
29	99	112	151	159	124	96	93	102	106	106	103	101
30	89	99	134	151	119	87	83	94	100	98	93	90

of April. If we examine still more closely for clues which may be of possible future service in the study of the reasons for accordance and discordance, we find that in nineteen instances the discordance is greater than we should expect if it were merely casual; in five, it is the same; and in forty-two it is less; as will be seen by the following statement of the numbers of discordances, and the curves by which they are severally shown:

EXCESS OF DISCORDANCE.

20, Aug.—Nov.; 19, Jan.—Mar.; Apl.—May, Apl.—Oct., May—Jul., May—Dec., Nov.—Dec.; 18, Jan.—Apl., Apl.—Jul., Apl.—Sep.; 17, Jan.—Aug., Jan.—Oct., Apl.—Aug., Apl.—Nov., May—Jun.; 16, Feb.—Aug., Mar.—May, Apl.—Jun., Sep.—Dec.

AVERAGE DISCORDANCE.

15, Jan.—Feb., Jan.—May, Feb.—Dec., Mar.—Apl., Jun.—Aug.

EXCESS OF AGREEMENT.

14, Jan.—Sep., Feb.—May, Mar.—Aug., Mar.—Nov., Apl.—Dec., Oct.—Nov.; 13, Jan.—Dec., Mar.—Sep., Mar.—Dec., Aug.—Sep.; 12, Jan.—Jul., May—Aug., May—Nov., Jun.—Dec., Jul.—Sep., Jul.—Dec.; 11, Feb.—Apl., Feb—Jun., Feb.—Jul., Feb.—Sep., Mar.—Jun., Jun.—Oct., Jul.—Aug., Jul.—Nov., Oct.—Dec.; 10, Jan.—Jun., Feb.—Oct., Feb.—Nov., Mar.—Oct., May—Oct., Jun.—Jul., Jun.—Sep.; 9, Mar.—Jul.,

---

TABLE V.

Normal Percentages of Rainfall at "Husband's," on Lunar Days of each Calendar Month, for Forecasts.

	Jan.	Feb.	Mar.	Apl.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
1	85	94	110	117	106	91	89	95	97	90	81	82
2	90	92	95	99	96	92	97	105	105	95	86	86
3	97	94	90	89	92	94	100	110	114	109	101	97
4	98	95	92	92	95	92	100	109	115	114	107	101
5	97	102	103	102	103	103	101	103	108	109	104	96
6	104	108	108	105	104	105	102	101	103	106	105	102
7	112	108	103	99	102	107	108	106	107	112	115	114
8	117	102	91	92	101	110	115	116	118	122	128	127
9	120	99	86	90	103	113	119	123	127	132	135	132
10	124	106	91	93	106	116	120	126	132	136	138	134
11	128	118	104	103	114	122	121	120	124	127	129	130
12	123	122	117	116	123	127	120	111	108	111	116	120
13	110	115	116	115	118	122	116	108	103	102	103	107
14	100	105	107	104	105	113	117	112	104	98	96	97
15	93	96	91	93	97	109	118	115	103	92	87	89
16	85	86	84	83	90	102	109	104	92	82	78	81
17	84	84	80	79	83	90	88	81	74	71	73	79
18	94	92	87	85	86	84	77	69	66	70	78	88
19	104	99	92	90	91	88	80	72	69	75	88	99
20	103	99	94	90	89	87	83	80	82	87	95	101
21	91	91	90	86	82	83	83	84	88	96	101	96
22	79	83	87	85	79	80	83	85	87	89	87	82
23	80	85	88	85	81	81	84	84	83	81	80	78
24	88	91	92	92	91	88	86	84	82	82	83	85
25	93	93	94	98	99	94	89	88	89	91	94	95
26	98	95	95	97	100	99	96	96	99	102	103	101
27	102	105	108	106	104	104	106	108	107	107	105	103
28	106	117	130	130	116	107	108	110	110	108	106	104
29	103	118	143	148	126	102	96	101	105	105	103	101
30	92	105	130	139	119	94	87	93	98	97	94	91

Jun.—Nov., Jul.—Oct., Sep.—Oct., Sep.—Nov.; 8, Aug.—Oct.; 7, Jan.—Nov., May—Sep., Aug.—Dec.; 6, Feb.—Mar.

The greatest amount of change produced by the lateral smoothing is shown in the following summary of comparisons between Table III. and Table V.:

	A.	D.		A.	D.		A.	D.		A.	D.
Jan.	22	8	Apl.	21	9	Jul.	26	4	Oct.	24	6
Feb.	26	4	May	19	11	Aug.	23	7	Nov.	23	7
Mar.	23	7	Jun.	22	8	Sep.	23	7	Dec.	18	12

Table V. is formed from Table IV. by taking two additional successive means. I am inclined to think that its normals would best represent the means of observations extending over indefinite long periods, but Table III. would perhaps more nearly indicate the disturbances of mean lunar influence that might be expected at different seasons of the year. It is possible that by systematically comparing monthly observations with each of the tables, probable causes for any marked deviations from the normals might be found.

Table I. presents three sets of solar and six sets of lunar normals, each of which is derived from observations extending over equal, but non-correspondent, periods of one hundred and eight months. They therefore furnish data for three entirely independent solar, as well as for seven entirely, and three nearly independent lunar comparisons. The lunar columns cover twenty-seven years' observations in the following months: Summer Solstice, May to August, inclusive; Winter Solstice, November to February, inclusive; Vernal Equinox, February to May, inclusive; Autumnal Equinox, August to November, inclusive; Vernal and Autumnal Equinox, March, April, September, October; Summer and Winter Solstice, June, July, December, January. The solar columns exhibit, as we might expect, the closest accordance. The lunar, in spite of the great irregularities in Spring and Fall, also exhibit a predominance of accordances in each of the ten comparisons, whereas, if there were no well-marked lunar action, we ought to have found a predominance of disagreements in five of the comparisons.

The accompanying curves illustrate some of the more important results of the foregoing discussion:

Curves 1–12 (Lunar), illustrating Table IV.

1. January.	4. April.	7. July.	10. October.
2. February.	5. May.	8. August.	11. November.
3. March.	6. June.	9. September.	12. December.

Curves 13–15 (Lunar), illustrating Table I.

13. Summer Solstitial, continuous line.
    Winter " broken line.
14. Vernal Equinoctial, continuous line.
    Autumnal " broken line.
15. Mean Equinoctial, continuous line.
    " Solstitial, broken line.

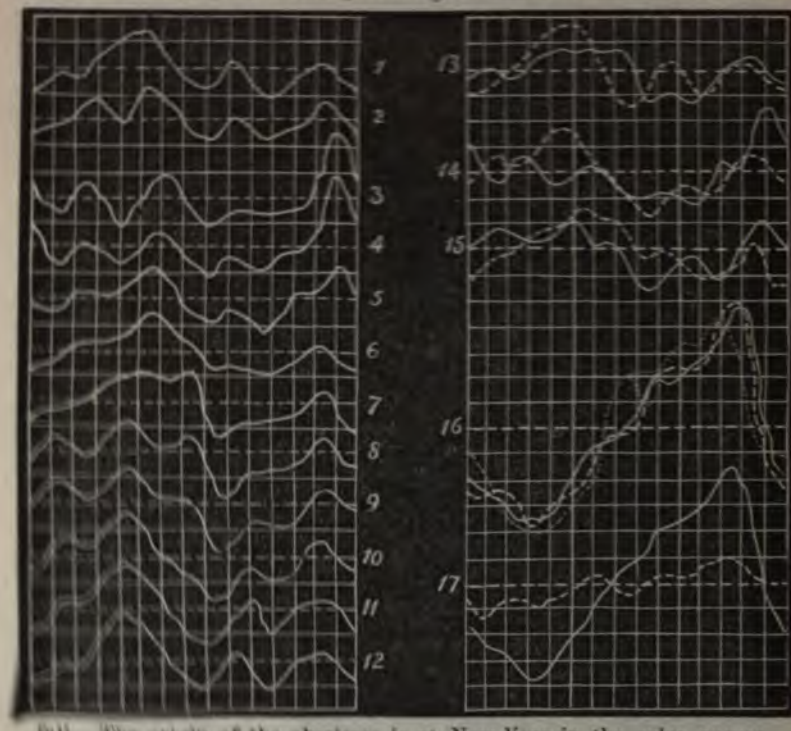
Curve 16 (Solar), illustrating Table I.

16. 1847–'55, continuous line.
    1856–'64, broken line.
    1865–'73, dotted line.

Curve 17 (Solar and Lunar), illustrating Table I.

17. Solar mean, continuous line.
    Lunar " broken line.

The horizontal line in each figure represents the mean daily rainfall for the entire period represented by the curve; the abscissas, the times; and the ordinates, the normal percentage of excess or deficiency of rain-



fall. The origin of the abscissas is at New Year in the solar curves, and at full moon in each of the lunar curves, except figure 17, where it is taken at new moon in order to show the analogous effects of increasing radiation, both in the solar and in the lunar curves. At Lisbon, where the prevailing winds are from an opposite quarter, the lunar influence is quite opposite, increasing lunar radiations and decreasing solar radiations, each bringing increase of rain.

"Husband's" Station is in St. Lucy's parish, northwestern part of Barbadoes, not far from the coast, 184 feet above the sea. In the following tables, new moon, first quarter, full moon, last quarter, are respectively marked by, n, a, f, b.

RAINFALL AT "HUSBAND'S," BARBADOES.

January 1st, to December 31st, 1847.

Days.	Jan.	Feb.	Mar	Apl.	May	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1	f	.23	f	.06			.05	.02	b .48	b .03	.25	.06	
2	.30			.10	.01		.01	.10	.04		2.90		
3	10			.07			.01	b .23	1.28		.70	.15	
4	.07	.01	.01			.01		.16	.23				
5	.05		.07	.11		b .06	b 1.67						
6	.07						.01	.10	.13	.04	.27		
7	.01		.07		b		.02	1.15	.31	.71	n	n .02	
8	.03	b		b			.36				.04	.01	
9	b 01		b .07			.07	.03		n .64	n	.03	.01	
10	.06		.05	.34		.63	.03	n .09	1.55	.73	.01		
11	.23	.01		.26			.01	.01		.17	.05	.01	
12	.16	.05	.01			n .11	n .51			.09		.14	
13	.14		.02	.12								.12	
14	.19	.15	.05	.16	n .48	.01		.25	1.34	.40	.99	a .01	
15	.05	n .06		n .03	.08		.04	.09		.09	a .79	.63	
16	n	.01	n			.10		.05	1.89	.09	.03	.24	
17	.28	.01	.10			.08		.10	a .04	a	.04		
18		.06	.10	.11		.03		a .05	.56		.04	.45	
19	.02	.09			.01			.05	.36			.01	
20	.25	.02	.01	.27		a	a	.02	.27	.28			
21	.23	a .02		.06	a		.05		.03			f	
22	.06	.02	.01	a .10		.04	.04		1.27	.03	f .53	.03	
23			a				.20	.10	.50	f .01	.26		
24	a .13							.02	f .22	.11	.11		
25	.02							.01	.16	.25	.07		
26	.04		.47				.36	f		.72		.33	
27	.04						f	.16	.05	.70	.03	.24	
28	.01	.01				f		1.80	.57	.66			
29			.13		f .04	.42		.02	.45	.43	b .51	b .03	
30	.02		.01	f .06	.06	.08	.05	.01		b .94	.50	.01	
31	f .05		f					.01		.30		.22	
Sum	2.62	0.75	1.00	1.85	0.68	1.58	3.45	5.00	12.37	6.78	8.25	2 72	

January 1st, to December 31st, 1848.

Days.	Jan.	Feb.	Mar	Apl.	May	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1	.35					n					.40		
2	1.34						.11		.13	1.12		.48	
3	.01			n	n		.13		.20	3.75	a		
4	.03	n				.04	.89			1.54	a		
5	.05		n					.37	a	a			
6	n .28					.27		a			1.50		
7	.03		.10		.18	.10	.32	2.95					
8	.02			.13		a	a	1.62	3.30				
9	.08	.01			a			1.52					
10		.05		a		.09		.19			f	f	
11		a .02	a .05									.49	
12	.05	.09	.06							f			
13	a				.43				f.23				
14	.03						.15	f	1.73				.31
15	.01			.09		.25		.13		1.78			
16	.15	.07				f	f.86		.03				
17	.36	.48	.31		1 04			.13			b	b	
18	.08	f	.01	f	f					.36			.19
19	.45	.01	f .04			1.25	.36		b	b			
20	f .05	.10			.37				1.50	1.50			.35
21	.15							b 1.75			.59		
22			.09	.07			.45						
23	.03		.16				b		.03	1.80	.13		
24	.08					b .21		.10					.50
25	.05	.08		.30	b	.35			.35		n	n	.23
26		.01		b				.31		n 1.15			
27		b .03	b				1.16		n				.65
28	b	.09			1.07			n		.20	.60		.37
29		.08					1.10			.78			
30				.31		n .05	n				.05		
31			.14		.94		.17	.13		2.25		.21	
Sum	3.68	1.12	0.96	0.90	4.03	2 55	5.70	9.20	7.50	16.23	3.27	3.78	

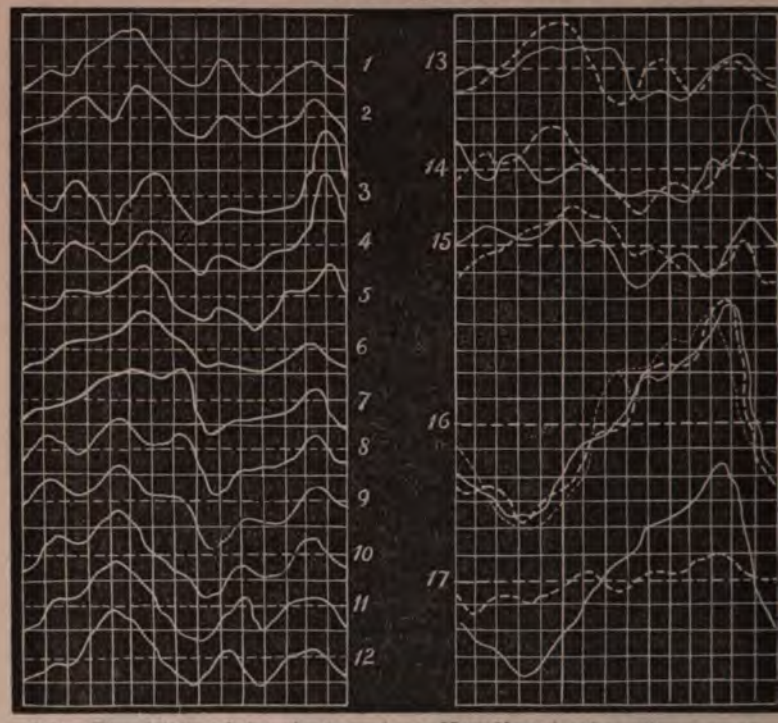
Curve 16 (Solar), illustrating Table I.

16. 1847–'55, continuous line.
    1856–'64, broken line.
    1865–'73, dotted line.

Curve 17 (Solar and Lunar), illustrating Table I.

17. Solar mean, continuous line.
    Lunar " broken line.

The horizontal line in each figure represents the mean daily rainfall for the entire period represented by the curve; the abscissas, the times; and the ordinates, the normal percentage of excess or deficiency of rain-



fall. The origin of the abscissas is at New Year in the solar curves, and at full moon in each of the lunar curves, except figure 17, where it is taken at new moon in order to show the analogous effects of increasing radiation, both in the solar and in the lunar curves. At Lisbon, where the prevailing winds are from an opposite quarter, the lunar influence is also opposite, increasing lunar radiations and decreasing solar radiations, each bringing increase of rain.

"Husband's" Station is in St. Lucy's parish, northwestern part of Barbadoes, not far from the coast, 184 feet above the sea. In the following tables, new moon, first quarter, full moon, last quarter, are respectively marked by, n, a, f, b.

RAINFALL AT "HUSBAND'S," BARBADOES.

January 1st, to December 31st, 1847.

Days.	Jan.	Feb.	Mar	Apl.	May	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1	f	.23	f	.06			.05	.02	b .48	b .03	.25	.06	
2	.30			.10	.01		.01	.10	.04		2.90		
3	.10			.07			.01	b .23	1.28		.70	.15	
4	.07	.01	.01			.01		.16	.23				
5	.05		.07	.11		b .06	b 1.67						
6	.07						.01	.10	.13	.04	.27		
7	.01		.07		b		.02	1.15	.31	.71 n		n .02	
8	.03	b		b			.36				.04	.01	
9	b .01		b .07			.07	.03		n .64	n	.03	.01	
10	.06		.05	.34		.63	.03	n .09	1.55	.73	.01		
11	.23	.01		.26			.01	.01		.17	.05	.01	
12	.16	.05	.01			n .11	n .51			.09		.14	
13	.14		.02	.12								.12	
14	.19	.15	.05	.16	n .48	.01		.25	1.34	.40	.99	a .01	
15	.05	n .06		n .03	.08		.04	.09		.09	a .79	.63	
16	n	.01	n			.10		.05	1.89	.09	.03	.24	
17	.28	.01	.10			.08		.10	a .04	a	.04		
18		.06	.10	.11		.03		a .05	.56		.04	.45	
19	.02	.09			.01			.05	.36			.01	
20	.25	.02	.01	.27		a	a	.02	.27	.28			
21	.23	a .02		.06	a		.05		.03			f	
22	.06	.02	.01	a .10		.04	.04		1.27	.03	f .53	.03	
23			a				.20	.10	.50	f .01	.26		
24	a .13							.02	f .22	.11	.11		
25	.02							.01	.16	.25	.07		
26	.04		.47				.36	f		.72		.33	
27	.04						f	.16	.05	.70	.03	.24	
28	.01	.01				t		1.80	.57	.66			
29			.13		f .04	.42		.02	.45	.43	b .61	b .03	
30	.02		.01	f .06	.06	.08	.05	.01		b .94	.50	.01	
31	f .05		f					.01		.30		.22	
Sum	2.62	0.75	1.00	1.85	0.68	1.58	3.45	5.00	12.37	6.78	8.25	2.72	

January 1st, to December 31st, 1848.

Days.	Jan.	Feb.	Mar	Apl.	May	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1	.35					n					.40		
2	1.34						.11		.13	1.12		.48	
3	.01			n	n		.13		.20	3.75		a	
4	.03 n					.04	.89			1.54 a			
5	.05		n					.37 a		a			
6	n .28					.27		a			1.50		
7	.03		.10		.18	.10	.32	2.95					
8	.02			.13		a	a	1.62	3.30				
9	.08	.01			a			1.52					
10		.05		a		.09		.19			f	f	
11		a .02	a .05										.49
12	.05	.09	.06							f			
13	a				.43				f.23				
14	.03						.15	f	1.73				.31
15	.01			.09		.25		.13		1.78			
16	.15	.07				f	f .86		.03				
17	.36	.48	.31		1 04			.13			b	b	
18	.08 f		.01 f		f					.36			.19
19	.45	.01 f	.04			1.25	.36		b	b			
20	f .05	.10			.37				1.50	1.50			.35
21	.15							b 1.75			.59		
22			.09	.07			.45						
23	.03		.16				b		.03	1.80	.13		
24	.08					b .21		.10					.50
25	.05	.08		.30 b		.35			.35		n	n	.23
26		.01		b				.31		n 1.15			
27		b .03 b					1.16		n				.65
28	b	.09			1.07			n		.20	.60		.37
29		.08					1.10			.78			
30				.31		n .05	n				.05		
31			.14		.94		.17	.13		2.25		.21	
Sum	3.68	1.12	0.96	0.90	4.03	2 55	5.70	9.20	7.50	16.23	3.27	3.78	

RAINFALL AT "HUSBAND'S," BARBADOES.

January 1st, to December 31st, 1849.

Days.	Jan.	Feb.	Mar.	Apl.	May.	Jun.	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1		.20	a			.05		.07		.78			
2	a					1.20			f .17	f		.72	
3						.19		f.40				.07	
4	.13								.70	.85		.03	
5						f	f .12					.01	
6					1.20					.30		b .26	
7		f		f	f	.14	.10	1.50	.07	1.75	b	.54	
8	f .35		f. 12		.49					b .42		.81	
9						.30		.23	b.50	.90		.01	
10	.04	.30				.38	.39		.75	.30		.05	
11	.20			.74	.11			b	.14	.05			
12							.54	.45		.02			
13						b	b .26					.01	
14	.32	b			.11		.87				n .04	n .04	
15				b	b	.37	.36		.78		.87		
16	b	.97	b.84		.42	.67	.11	.84	n	n			
17						1.00			.33	.05	.05		
18							.14	n	.24	.32			
19				.42			n			1.20			
20	.33					n .15					.25		
21		.60											
22		n	1.04	n	n			1.40			a .02	a	
23			2.12				.87				.03		
24	n		n				.18		a	a			
25	.52				.05	.05		a .08	.12	.55			.36
26	.87	.14		.44	.22	1.35	a						
27						a .95	.14						.02
28		.04			a		.58						.04
29	.57			a					.85	.05	f .14	f	.01
30					.36	.14	.58		.60				.05
31	a .67		a				.56			f			
Sum	4.00	2.25	4.12	1.60	2 96	6.94	5.80	4.97	5.25	7.54	1.40	3.03	

January 1st, to December 31st, 1850.

Days.	Jan.	Feb.	Mar	Apl.	May	June.	July	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1		2-08	.06	.08		.15		b .02	.09			2.70	
2		.11		.02		b .05	b	.20	.27			2.10	
3	.49	b				.51	.25			.11	n	n .03	
4	.04			b .03	b	.28	.27	.22	.02	3.06	.13	.23	
5	b		b	.08				.15		n .26	.16		
6				.02	.16		07	.95	n			.25	
7	.02	.40		.02	.42			n .15	.09	.02		.05	
8	.01						2.75		.02	4.35	.05		
9						.15	n .28	.05	.18			.07	
10						n .45	1.13	.28	.14			.11	
11		.10			n .14			.28			a .55	a .11	
12		n		n			.10		.03	a .02	.17		
13	n .25		n .06					.02	a .07		.02		
14				.30		2.90	.48	a .10	.17	.18			
15				.16			.65	.22	.23	.44		.09	
16			.44	.06		a.45	a .04	.84	.08	.16		.07	
17		.04					.49	.62		.10	.82		
18				.05	a		.22				.02	f	
19	.16	a		a 3 00	.10		.18			.41	f	.08	
20			a	.08		.06				f	.08	.12	
21	a	.30				.30		.12	f	.15	.08	.02	
22		.08						f .01			.50		
23					1.67		.06				1.74		
24		.25				f	f .03	.02	.06	.13	.04		
25				.08	f	1.25	.11		.25		.02	b .10	
26		f.14		f .38			.36			.13	b .06		
27	f		f .24				.15	.09	.73	.19	b .54	.15	
28							.80	.35	.82	b .33	.05	3 82	
29								.02	.11	.04	3.00	1.50	
30					.05	.30		b 2.40	.10	3.20	.67	.07	
31	.15				.16		.35	.97		.15		.04	
Sum	1.12	3.50	.80	4.36	2.72	7.80	8.28	9 28	2.36	15.92	10.97	6.39	

RAINFALL AT "HUSBAND'S," BARBADOES.

January 1st, to December 31st, 1851.

Days.	Jan.	Feb	Mar	Apl.	May	June.	July.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1		n .05		n	n				.18 a				
2	n	.03 n							a	1.05	2.02	.41	
3	.08				.73			a	.15	.10	.11	.24	
4	.04	31	.03								.02		
5			.04				a	.50	.04	.22	.31		
6	07					a	.65		.54			f .32	
7			.03	.24			.31		.04	.13	.08	.03	
8		.03	.04		a			.15			f		
9	.04 a			a			.09				.03	.80	
10	a .12		a		.39	.22	.07		f	f .02	.18	.11	
11						.19	.04	2.69					
12		.50	.13	.90		.36			08		.03		
13	.12	.13	.57			f	f	.94	2.78	.48	.90		
14				.25	.07	.26	.18		.77	1.46	.83		
15	.07 f	.12	.24 f		f		.03			3.74		b .11	
16	.03	.25	.04		.82	.73	.44				b .10	.39	
17	f .03	.36 f				1.25		.67		b		.27	
18		.09			.11	.18	.51		b			.09	
19	.04					.32	.09 b	.04		1.21		.19	
20						.05	.04	.54		.24		.11	
21						b .23	b	.24	.58		.14		
22		b .42		b	b	.22	.15	.04	1.07	.25 n		n .28	
23		.04		.20		.20	.40	.30			.11		
24	b .07		b		.22	.04		1.86		n.57	.05		
25	.10	.03		.03			.31	.08 n	.26		.20		
26						.15	.18 n	.05		.36		15	
27	.03			.02	1.02	.70			1.10		.40	.25	
28						.91 n	.17	.12	.15	.15		.16	
29	.05			.08		n	.42					.02	
30					n .09		.64	.08	.04		a .05 a	.09	
31	.16							.50		a			
Sum	1.05	2.36	1.12	1.72	3.45	6.01	4.72	8.80	8.38	9.98	5.56	4.02	

January 1st, to December 31st, 1852.

Days.	Jan.	Feb.	Mar	Apl.	May	June.	July.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1		.03				.45	f .04				.04	.09	
2					.01 f						.01	.07	
3			.05		f	.12	.18				.15	1.10	
4		.35	.16 f		.11	.03	.36	.04			b .35 b		
5		f .22				.04	.22		.32		2.05	.21	
6			f .13			.07	.04	.11	b .22 b		.37	.01	
7	f		.14			.05	.10	b .27	1.65		1.15	.05	
8	.30	.12	.02			.03	.10		.51	1.21	3.78	.05	
9	.12	.03				b .18	b	.68	.02	2.74	.60	.06	
10		.32	.08		b					.13		n	
11	.30	.04		b		.09	.01	1.40		.03 n		.05	
12		b	b .48		.13		.04	3.30	1.20			.20	
13	b .27	.18	.36	.01	.03		.16	.02	n .94 n		1.76	1 04	
14	.10		.16	.96	.14	.23			.01	.34		1.30	
15				.01				n .09	.01				
16	.24					.14 n	.26	.07			4.05		
17	.05			.02		n .03		.07				.21	
18	.06	.02	.25		n .05		.04	.01			a .52 a		
19	.02 n	.20		n			.27	.08		a		.06	
20	.07		n					.02 a			2.86		
21	n .12				.14	.02							
22		.08			.66	.06	.14 a		.41				
23	.35	.01			.12	.31 a	.02	.29	.32				
24	.12	.09				a		.15	.09				
25	.19				.25	.04	.01	.03				.05	
26		.03	.19	.27	a .08	.10	21				f	f	
27	.07			a	1.70	.02	.01			f		.26	
28		a .01 a			3.22	.76	.14		f				
29	a .07	.15					f .09	.26		1.31		.35	
30	.10			.10		.01	.03	1.09	.07	4.37		.03	
31							f					.05	
Sum	2.55	1.88	2.02	1.37	6 64	2.78	2.38	7.81	6.03	10.13	18.29	5.24	

RAINFALL AT "HUSBAND'S," BARBADOES.

January 1st, to December 31st, 1853.

Days.	Jan.	Feb.	Mar	Apl.	May.	June.	July.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1		b .27		.31			.20	.06	.03	.82	n .20	.05	
2	b .08	.16	b			1.14	.02	.11	.04	n .01	.22	.15	
3	.29	.85	.18			.69		1.64	n	.82	.20	.55	
4		.03						n .10			.05		
5	.23		.12	.16			.10	.15	.02	.08	.82	.01	
6			.12			n	n .57			.10	.02		
7	.14		.04		n .23	.02			.26	.01	a 1.09	a	
8		n	.26	n .04	.45	.19	.14	.06	.01		.20		
9	n	.14	n .04	.09	2.23	.05	.12	.19	.13	a .02	1.83		
10		.85	.39	.06	2.28		.12	.03	a	.73	.31		
11			.32	.10			.85	a .19	.12				
12	.26	.60	.25	.26				.08	.02	.05	.01		
13	.20		.01		.21		a .09	.37	.85				
14			.08			a .04			.05	.07	.04		
15		a .01	.18	.05		.08	.05			.01	f	f	
16				a	a		.05			f	.48		
17	a	.02	a .03	.01		.11	.18		f .65	.68	.20	4.50	
18			.08	.02		a .60		f .03	2.37	.24	.05	.11	
19			.17	.04			.21	.11	.13		.10		
20			.08	.14		.03	f	1.20		.08	.01		
21				.29		f .03		1.16		.80			
22	.05		.03		f 3.77	.07		.14	.05	.46	.18		
23	.02	f	.06	f .34		1.20	.11	.10	.07		b .36	b	
24			.05	.13	.03				.48	.15	.01		
25	f		f .01	01			.02		b .05	b .35	.09		
26	.06	.02		.04		.11	.09	b .20	.02	.85	.45	.64	
27	.06			.03		.09	b .85	.40	3.23		.33		
28	.12	.02	.12	.25	.11	b	.22		3.61		.01		
29	.28			.09	b		.28	.02	.01	1.42		.15	
30				b		1.10	.02	.02	.06		n .01	n .01	
31	.69		b		4.28		.03	.39					
Sum	2.48	2.97	2.62	2.46	13.59	5.55	4.26	6.75	12.26	7.75	7.27	6.17	

January 1st, to December 31st, 1864.

Days.	Jan.	Feb.	Mar	Apl.	May.	June.	July.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1			.01	.23		57		a .04	.60	.45	2.27		
2		.15		.05		.03	.40	.14				.20	
3			.15	.11		a .40	a .63	.02		.24		1.21	
4		a 01	.03	.08			.29			.23	f	f .25	
5	a .03	04		a .13	a	.03		1.59	.04	.95	.67	.15	
6			a .01	.01			.05		f .03	f	.28	.07	
7				.04			.62	.02	.14	.30	.16		
8						1.35		f	.02	.09			
9		.11					.05		.58		1.64		
10	.16		.06			f .06	f	.06	.65		2 50		
11			.32			.40	.08		.01		3.25		
12	.28	f			f	.15	.19			.77	b 2.90	b	
13			.01	f		.01	.15		.02	b1.07	.65		
14	f .40		f	.05	.01			.01	b	.30	.07		
15	.29	.11	.01	.25	.17		.28	b .22	.19			.87	
16			.02		1.14	.02	b .05	.01	.01	.09			
17		.01			.02	b .20	.01		.23	.11		.12	
18		.05	.08			.06	.02			.44			
19			.07	b	b					1.84		n	
20		b	.01		.08				.02		n .20	.24	
21	b		b				1.63	.11	.11	n .07	.17		
22						.27	.05		n .09				
23	.19	.14				.15	.39	n .09	.07				
24							n 1 95		.18			.04	
25		.15				n	.04		.18	.17		.06	
26	.11	n			n .13	.20		.19		1.21	a	a	
27	.16	.04		n .07		.68		.68	.44				
28	n .21	.03	n			.86	.44	.15	.01	a			
29						.05	.07	.40	a .04	.21			
30			.30				.90	.23	.01				
31	.02		.04					a .16					
Sum	1.85	.84	1.12	1.02	1.55	5.49	8 29	4 12	3.67	8.54	14 76	3.21	

RAINFALL AT "HUSBAND'S," BARBADOES.

January 1st, to December 31st, 1855.

Days.	Jan.	Feb.	Mar	Apl.	May	June.	July.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1	.25 f		.16		f .70	.15		1 20	.22	.60 b	.09 b	.60	
2	.30			f	1.66			1 01		b .48	.33		
3	f	.24 f			.55			.02 b	.05				
4	.04	.09						b .51	.15				
5	.71						.31	.08	.32		.24	.64	
6	.46	.15					b .04	.03	1.21		.30	.64	
7			.19			b .10	.11	.13			1.22	.06	
8			.79		b	.81		.10	1.05				
9	.57 b		.06 b					.38			n	n	
10	11	.05 b			.20		.90	06	.35 n				
11	b1.76					.65	3.00	1.64 n	.73				
12	.12				.14		.45 n	.33				.86	
13	.11	.08	.31				n	.05			.28		
14	.39				.28 n		.15	.03		.50	.03	.09	
15				.14 n			.04		.31	.26	.10		
16		n		n		.30	.20	.03	.69		a .15 a		
17			n			.09	.08		2.10	.10			
18	n	.20		.02			.20	.22	.05 a				
19							.40	.24 a					
20							.30 a	.03	.05			.86	
21	.39			.18		.35		.23					
22		.08	.05	.20		a .60 a				.05	.04	.10	
23		a .18	.06		a. 09	.90				.60 f	.81 f	.05	
24	a	.28		a .14	.38	.20	.10	3 20	.55		.05		
25			a			.25	.44	2.84 f		f .13	.10		
26			.50			.15				.73	.81		
27				.05		.30		f .73		.69	.25	.05	
28				.10		.63		.06	.01	1.06		.04	
29				.90	.20 f	.21 f	.10	.01		.10	.31		
30				2.20	.54	.05	.50	.15	.50		.26	.08	
31					f .14		.10			.10		b .18	
Sum	5.21	1 35	2.12	3 93	5 18	5.74	7 42	13.31	8 34	5.40	5 37	4 25	

January 1st, to December 31st, 1856.

Days.	Jan.	Feb.	Mar	Apl.	May	June.	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1	.31			.12		.11	50		.11		.02		
2		.05		.18		n	n .11				.18		
3		.02		.27			.56		1.08		.53		
4	.17		.32		n	.31	.07				.15	.12	
5	.20 n	.40	.44 n			4 20		.10			a .25 a	.16	
6		.30 n		.18				.08			2.34		
7	n .25	.10		.02			.12	.70 a		a	.03	.73	
8	.08	.18	.04					a 1.30		.08		.75	
9		.03				.07	1.05	.88	.73	.04			
10						a .02 a	.10	.17	.18			.27	
11		.07			a		.28		.13		2.23 f		
12	.25	.10	.35 a		.20			.58		.03 f	.02		
13		a .40 a						.77	.72 f		.29	.34	
14	a .10	.02							f .25	.25	.02		
15	.05							.05				.05	
16	.05	.12						f		.22			
17	.02						f .10		.22	.09		.01	
18						f	.28			.32	.35		
19		.25			f						b	b	
20		f		f	.09	.01	.18			b .07	.13	.05	
21			f	.01	.34		.05	.04 b			.02	.45	
22	f				.39			b .07	.80		.36		
23				.01	.41		.20	2.55	25	.06	.03		
24							b .01	.33	.27				
25						b .03	.32	.45		.96			
26		.02		.50		.03	.05			.02		.02	
27				b	b .22		.40	.10			n	n .05	
28		b			.41	.14			.06 n		.07		
29	b		b				.65		n	.02		.04	
30								n		.74	1.12	1.01	
31					.35		n			.14		.36	
Sum	1 48	2.06	1.15	1.29	2.42	4.94	5.03	8 17	4.80	3.04	8.14	4.41	

RAINFALL AT "HUSBAND'S," BARBADOES.

January 1st, to December 31st, 1857.

Days.	Jan.	Feb.	Mar	Apl.	May	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1	.09	a		a		.09		.14	1.80		f .55	f .10	
2		.07	a		2.75			.28			.93		
3	a .02	.03			.05	.05	.80		f .06	f .07	.01		
4			.26	.16	.06	.17	.68	.24	1.00	.28			
5			.05		.38	.10		f .58	.41				
6		.37	.29	3.80	3.35			4.60	.28				
7		.12		.02		f .12	f .07		.04				
8		f .03	.09	.46	f			.12	.22		b	b	
9		.19		f	.20	.03		.20	.67		1.00	.31	
10	f	.88	f			.42		.30	b	b	.06	.03	
11		.10		.06		1.42	.06	.70	.08			.16	
12		.50	.68			.17	.90	b .25			1.35		
13		.01	.07			.28		.18		.01	.28	.10	
14			.38			.52	b			.01	1.29	.07	
15	.15		.26		.21	b .06			.02	1.21	.18	.25	
16		b .20	.11		b		.11	.35	.82	.08	n	n	
17	b .10			b		.10	1.08		1.42	n .06	.95	.01	
18	.10		b				.05	.05	n .16	.48			
19	.04	.72					.41	n		.07	.06		
20	.06	1.51					1.42				.09		
21	.11	.03		.10		n	n .47		.40	.19			
22	.14	.22				.10		.31	.20		1.06		
23	.70	.17	.33		n .31	.06	.22	.13	.68	.40			
24		n .34		n		.45		.51	.07		a	a	
25	n		n			.66		.03	.10	a			.05
26	.11				.10	.85		.02	a .30		.50		
27		.02				.23		a .75					.07
28						a	a .16	.56		.17			.20
29					.05	.21	.52	.06	.18	1.78			.50
30	.10			a .27	a		1.20	.17	.20	.08	1.86		.08
31	.12							1.14		.06		f	.22
Sum	1.84	5.51	2.52	4.87	7.48	6.09	7.65	11.67	9.01	4.99	10.17	2.15	

January 1st, to December 31st, 1858.

Days.	Jan.	Feb.	Mar	Apl.	May	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Tota
1									.54		1.21		
2	.15	.14					.20		.10	.04	1.00	.01	
3	.03	.40			.79		.18				.18		
4		.60				b	b	b	.40	.13			
5	.10	b .10			.02		.65			.04	n	n	
6	.15	.04		b .08	b	.31	.20	.05		1.57	.58		
7	b .25		b .08			.05		.14	n	n .70	.40	.78	
8	.10			.10	.07	.34	.35			.30		.07	
9							.30	n .31		.40		.54	
10	.01					.09	n		.01	.35	.12		
11	.02	.01			.02	n .23	.22	.13	.36	.42	.03	.02	
12			.10	.10	.05	1.01	.23	.16		.10	.11	.06	
13	.08	n		n	n	.10	.30	47	1.00	.16	a	a .16	
14			.30	.30	.03		.33	.07	.25	1.30	.01	.08	
15	n		n				.15	.25	a	a .51		.28	
16	.21				.05		.10	a			.10		
17						.09	a				.10	.11	
18	.09	1.60	.02	.02		a	.08		.02		.10	.36	
19					a .14			.04			.07	.05	
20		a		a	.06	.15	.28				.19	f .52	
21	.02				.13		.03	.90			f		
22	a		a .25	.25						f			
23							.29		f .10				
24							.08	f .04	.46			.10	
25					.05		f	.17	.18				
26	.05					f .22			.79		.30		
27	.02	f			f .02				.16	.77	b 1.30	b .12	
28				f	.23			.17	.21	.52			
29	f		f		.11	.03	.55			b 1.00		.65	
30							.40	.40	b .12	.04		.13	
31					.17			b		.72		.01	
Sum	1.28	2.89	.75	.85	1.94	2.62	4.92	3.30	4.70	9.07	5.80	4.05	

RAINFALL AT "HUSBAND'S," BARBADOES.

January 1st, to December 31st, 1859.

Days.	Jan.	Feb.	Mar	Apl.	May	June.	July.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1	.04	.02					.03		.06	.30	.04 a		
2	.03	.25			n	.03		.65		a	.60		
3	n	.03		n	.03		.02	.07	a		.48		
4	n .04	.10 n				.06		.43 a	.67	.10	1.54	.07	
5	.03	.01						a	.01		1 40	.44	
6	.07		.03			.15				.64		.21	
7	.02	.05				a .15	a .23			.20		.97	
8		.01					.15	2.19		.08	.14		
9		.27			a	.12	.05		.50	12	.02		
10	a			a .07						.31 f		f	
11		.14		.16		2.00			f	.08		.08	
12	a	.05 a					.31		f	.14			
13				.02			.08 f		.02	.22	.51		
14	.23	.01	.06				.28		.18	1 34	.36		
15	.04			.11	.10 f		f		.40	.05	.08	.08	
16		.05			f .01	.30		.06	.20	.04	.30 b		
17		f	.03 f			.45			.18		b .09		
18	f .03	.07 f				.09	.24		.20	2 02	.06		
19	.03	.15	.07						b	b			
20	.06	.05			.23		.22		.05				
21	.05				.20	.12	.05 b	.26	.18	.08	.11		
22	.17		.31		.06	.53	.38						
23						b .36	b 1.35				.10		
24	.20 b				b	.20	.07		1.00		n	n	
25	b			b .30	.15	.33	.94		.18	.04	.07		
26			b	.01	.33	.15	.02		n	n .54	.10		
27	.18				.53	.54		.24		.37	.04	.18	
28	.09	.68		.03	.28	.04	.07 n		.03	.22	.08		
29					.06	.01 n			1 00	.04	.10	.16	
30					.65 n	.68				.01		.13	
31					n .20		.08			.08		.41	
Sum	1.31	1.94	0.50	0 70	2 83	6.31	4.57	3.90	4 86	7 02	6 22	2.73	

January 1st, to December 31st, 1860.

Days.	Jan.	Feb.	Mar	Apl.	May	June.	July.	Aug	Sep.	Oct.	Nov.	Dec.	Total
1	a .05	.18	.15						.09	.05	.06		
2		.17						1 05	5 95	.07	1.58		
3	.26	.05	.11			f	f .10		.01	.01	.19	.02	
4	.03	.21				.16	.04	.20	.23	.02		1.34	
5		.16		f	f			.39		1.96	.75 b		
6		.05		.14				43	02	.10 b			
7	.04 f	.04 f		06		.19	.21	.72	.61 b	.06		.35	
8	f	.20			.09			3.42 b	.04	.04		.24	
9	.03					.05	.38 b	.02		.14	.05	.02	
10	.26									.77			
11	.25			.11	.27 b		b			.86	.24		
12	.26	.04		.09 b		.23		.12	.14			n	
13		b		b	.01	.09			.69	.20 n			
14	.03		b				.09		.04 n	.22			
15	b .07	.07	.01			.07	.13		n 1 32			.14	
16	.01					.04		n .85	.41	.41	.05	.08	
17	.15	.04		.07		.38	1.00	.10			4 35	.02	
18	.03		.04			.63 n		.06	.02	.30		.03	
19		.12		.02		n .07	.17	.11	.25	.11	.50	.21	
20		.02			n	.02	.26	.57	.10	.10 a	.02 a	.08	
21		n .30		n			.08		a .02 a	.11	.05	.40	
22	n	.28 n						.20		1 67	.07	1.81	
23	.01	.01					.31 a	1.70	.05	.08	.04		
24							.45		.03	.57	.08		
25				.20		a	a .30		.34	.04			
26		.15					.10	.05	.15	.02	.07		
27		.08		.05 a			.08		.20	.02			
28		.10		a .13					.42	.08 f		f	
29		a .70		.11		1.05		.24	.45 f	.01			
30			a			.01	.29	.12 f	.12				
31	a				.37			f .63					.20
Sum	1.48	2.97	0.31	0.98	0.74	2.99	3.99	10.98	11.70	8.02	8 10	4.94	

RAINFALL AT "HUSBAND'S," BARBADOES.

January 1st, to December 31st, 1861.

Days.	Jan.	Feb.	Mar	Apl.	May	June.	July.	Aug.	Sep.	Oct	Nov.	Dec.	Total
1	.15		.01	.46 b		.21	.08		.10			.11	
2	.01 b	.42		b .07		.04	2.54				n	n .03	
3	.06		b	.01	.20	1 14	.63						
4	b .16	.02	.09		.10	.12		.02 n		n			
5						1.37	.96	.14	.04	.20			
6				.70	.11	1 13	n	.17	.18		.50		
7			.22	1.35	.34	.05	.12	.91	.13		.37		
8			.04	.20	.29 n	.60 n		.05		08	.60		
9	.07 n			.35 n	.03	.10	.42		.43	1 52 a		a	
10				n	.08	.14	.46			a .01			
11	n	.64 n				.01	.85	.77 a	.05	.15			
12	.03	.36		.04	.03				.03	.04			
13	.28			.16	.10		.46 a	.02	1 20	.06	.04		
14	.05		.03	.75		.05	.35		2.94	1 20	2.21	.23	
15	.37	.15	.02	1.50		a 1.85 a	.03		30	2.00		1.46	
16	.14			.01	.02	.06				.55	1 69	.17	
17	.08 a	.10		.20 a		.53		.58		.55 f	.03 f	.50	
18				a		.08		.03	.14 f	.47	.79	.59	
19	a		a .04		.11	.18		.10 f	.14	.30	.04		
20		.80	.20	.06	.09	.16	.10 f		.13	4.00			
21		.21	.01		.02			.01		.21	.08		
22			.06	.65	.19 f	04 f			.41	.06			
23	.79		.01	.55	.22		.40		2.24		1 05		
24	.03		.05 f	f	.33	.01	1.20		.10	.80	.11 b	.03	
25	.31 f	.08		.02	.03	.16	.03	.02		b	.82		
26	f .25		f .04	.05	.03	.52				b	.32		
27		.20	.01		.20	.06	.14		b				
28		.20	.30		1.50	.26		b .02			.05	.64	
29	.05		.03	.10	.87	.02 b			1.73	.40		.66	
30			.14	.27	2.28 b			.03			.31	28	
31	.13				b1.00		.30	.38		4.00		n .46	
Sum	2.96	3.18	1.30	7 50	8.17	8 89	9 07	3.25	10.29	16.62	9 01	5.21	

January 1st, to December 31st, 1862.

Days.	Jan.	Feb.	Mar	Apl.	May	June.	July	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1	.04	.02			.08				a .30	.07		.09	
2	.06		.04				1.00	.04		.03			
3	1.56		.02			.02		a		2 35			
4	.02					.10 a		.47	.01	6 00	.05	35	
5				.36	.09 a	.13	.32	.60	.07	1.27	.05		
6	.15 a				36					1.61 f	.38 f		
7	a	.14		a	a .06	.07	.17	15		f	.12		
8	.10	.02 a				2 00	.07	.09 f				.02	
9	.04					.15	.09 f	.10	.35				
10	.02	.04	.06					.23		2.10	.38	.49	
11	.02			.06	.06		f .01		.15			.69	
12	.10	.40				f .06				.10	1 05		
13	.15				f	.07		.04		.06	2 05		
14	.14 f	.38	.07 f		.57		.31				b 3 03 b		
15	.11				.44			.10	.13 b	.07	.60	.02	
16	f .15	.12 f				.46		.05 b		1.85	.04		
17	.05			04			.75 b	.15	1.00	.04	.70	.07	
18	.03						b .22		.06		.25		
19	.06			.06		b .29		38			.25	.19	
20	.05				b .03	.06	.06	.26	.04				
21		b	.03 b	.16		.04	.34	.30	.04	.12 n	1.20 n		
22	.05		b				.11			1.50	.70		
23	b .46			.02	.23	.03		.13 n	n			.82	
24	.74		.12	.18	.51	.02		2 65					
25	1.00			.42	.91	.45	n	2.06	.64		.02		
26					.04	.08 n		.30	.01				
27	.05					n 94	.20		.03				
28	.25 n			n	n	.75			.18		.07 a		
29					.05		.03	.30		1 60 a		.01	
30	n		n	.04					a	a	.04		
31										.07			
Sum	5.40	1 72	0 34	1 84	3 43	5 72	3 68	8 40	3.01	18.84	10.98	2 65	

RAINFALL AT "HUSBAND'S," BARBADOES.

January 1st, to December 31st, 1863.

Days.	Jan.	Feb.	Mar	Apl.	May	June.	July.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1		.37	.03	.05		f	f	1.67		.64			
2		.02	.01	.68								.35	
3		f .06		.20 f			.04		.14	.14 b		b 1.20	
4		.09		f			.57	.24		b	1.54	.01	
5	f	.06 f	.02	.03				.80 b	.15	.02	.57		
6	.01	.30		.04		.08	.37 b	.10			.29		
7		.02				.04 b	.04	.07	.02	.65	.30		
8			.02	01		b	.10			.05	.30		
9	.11	.43				.46	.16	.05	.02		.29	.14	
10		.05	10	.12 b	.71			.20	.05	.06		n .06	
11		b	.09 b	.03	.11		.12	.03	.16		n	.08	
12	b		b .05			.05	.10	.03		n	.08		
13				.06		.11		.05 n					
14		.11		.11		.15	.20 n			.07			
15	.02	.65		.08			n 1.35	.04	.24		1.80	.18	
16	.20	.03		.12		n	.04		.36	.31	.27	.07	
17		.05			n .10			.15	1.50		.10 a	.05	
18		n .02		n .08	.02			·15		.45 a		.12	
19	n		n		.14				.04 a	.04	.58		
20			.08	.02	.02	.08			a .17		.45		
21		.04	.08	.38		.23			.17	.02	.05	.04	
22		.05	.06	.06			.45 a	.02	.05	.03	.42	.50	
23		.09	.09		.03	.04 a	.11		1.11			.20	
24	.07	.04				a		1.07				.04	
25	.09 a	.33		.03 a		.32				.08 f	.04 f		
26	a	.65		a .10		.06	.25	.33		f	.17	.05	
27	.09	.50 a				.04	.20	.48 f				.12	
28	.11	.11					.03 f	.40	.08	.10			
29	.09		.29					.11	.40		.12		
30	.05		.02				f .02			.02	.47		
31	.02		.25				.05						
Sum	0.86	4 13	1 19	2.20	1.13	1.66	4.20	5.99	4.66	2.68	7.84	3.21	

January 1st, to December 31st, 1864.

Days.	Jan.	Feb.	Mar	Apl.	May	June.	July.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1	.05		b					.03 n		.05	.14	.02	
2	.40	.18					.01 n			.35	.42	.20	
3	.44	.07				.09	.33	.84		.12	.02		
4	.30					n .04 n			.12		.30		
5	.20				.18	.03			.66	1.45	.38	.02	
6	.14			n	n		.11				a .01 a	.07	
7		n .05		.03			.54		.02		.02	.10	
8	.05	.04 n					.09			a	4.16	.05	
9	n .03						.02		a .10	.72	.66	.07	
10	.04		.06				.06 a	.79		.03	.30	.30	
11	.03			.21			.18		.01			.30	
12		.03				a .06 a		.22	1.54	.03	.28	.45	
13	.28	.07			a	.03	.46		.33		f	f .27	
14	.10 a			a	1.20	.02		.21	1.75	4 55		.04	
15	a .08	.05 a			1.25			.10 f	.40 f		.01		
16							.17	.11	.43		.15	.30	
17	.12						.50 f	1.30	.46	.61	1.24	.20	
18	.16	.20	.20		.06	.22		.32	.46	.05	.02	.01	
19	.05				.12 f	.04 f	.48	.06	.33	.02	.03		
20	.12	.17			.04	.04	.52	.03	.24	.39	.01	.30	
21	.28	.14			f .01	.02	.07			.90 b	.43 b	.38	
22		f .32		f			1.22	.03 b	.22 b	1.45	.21	.03	
23	f		f			.03	.06	.64	1.45	.15	.26	.03	
24		.05					1.31 b	.13	1.23	.56	2.41		
25		.09					b .75	.56	.06				
26	.03	.08				b	.06	2.20		.10			
27	.12					.54		1.14	.34	.82		n	
28		.06			b .03	.03	.03	-	.32	.20 n			
29	.05	.02		b	.03		.10				.66	.02	
30			b	.05	.01		.04		n	n		.16	
31	b							.21				.25	
Sum	3.07	1.62	0.26	0.29	2.93	1.19	7.11	8.92	10.47	12.55	12.12	3.57	

RAINFALL AT "HUSBAND'S," BARBADOES.

January 1st, to December 31st, 1865.

Days.	Jan.	Feb.	Mar	Apl.	May	June.	July.	Aug	Sept.	Oct.	Nov.	Dec	Total
1	.03	.25		.08		a .19	a	.53			1.10	.10	
2		a			a		.36	.17	.03	.02	.03 f	.16	
3		.05	.07 a			.90	.88	.18	.31	3.85 f		.14	
4	a .10	.04 a				.91	.55	.18	.11 f	.15	.06		
5	1.10			.01			.15	.75 f	.24	.02	.03		
6				.02	.05			.04		.09	3.25		
7		.05	.01		.07	.30	.43 f	.05	.08	1.40			
8		.14		.50	.15	.10 f	.08		.30		.01		
9				.29	1.42 f		.03	.02		.55			
10		f		.15 f	.15			.53	.03		b	b	
11	f	.07		f	.26	.02		.25	.45 b	.13			
12			f		.26		.29	.27 b		.56			
13			.03		2.45	1.20	.01 b	.41	.18	.35		.05	
14	.03	.01			.08	.58	.14	.56				.39	
15	.56	.02		.10		.15 b	.70	.04				.17	
16			.50		.70 b	1.58	.17	1.91				.11	
17		.04	.08	.05	1.25	.42	.04	.01				.13	
18	.16 b		.01 b	.07 b	.02	.48	.04	.03			n	n	
19	.03			.30		.15	.80	.04 n	.88 n	.20	.16	.43	
20	b .03		b			.54	.01	.03		.96	.04	.39	
21	.06					.05	n	.75		.82	.38	1.65	
22	.05	.70			.02	.01 n	.06	.35			.41	.04	
23			.01	.13	.12 n	.03	.12	.09		.21			
24			.39	.04 n			.17	.36		.20			
25		n	.22 n	.17			.38	.03		.20	.05 a	.23	
26				.04	.04	.09	.50	.45	.37	.03 a			
27	n	.07 n		.11		.68	.04	.32		a .03			
28				.02	.29			.07 a	.02	.21			
29					.05	.17		a	.28	.50		.52	
30	.77		.05		.10	.53 a		1.03	.05	3.25		1.41	
31	.02				.29		.10	.37		2.69		0 28	
Sum	2.94	1.44	1.37	2.08	7.77	9.08	6.05	9.80	3.33	16.42	5.52	6.20	

January 1st, to December 31st, 1866.

Days.	Jan.	Feb.	Mar	Apl.	May	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1	f .21		f				.03	.03	.79	.06		.54	
2	.16	.03				.11	.70	b		.29	.14	.91	
3	.20					.11	.07 b	.38		.45	.14	.39	
4			.04				.50	.04	.13	.15	.30	.96	
5		.04		.11		.03 b	.01	.11	.01	.77		.10	
6	.03	.14			.03 b		.29	.04		.01		.09	
7		b			b .67			.01	2.30	.26 n	n	.24	
8	b .09	1.00		b			.21	.03	.05 n	.31	.06	.04	
9		.26 b					.41	.03 n	.03				
10	.03	.11				.05	.05 n	.76	.07		.20	.49	
11	.07	.10			.01	.02	.12	1.45		.60	.01	.76	
12		.30	.43			n	n 2.40	.43		.10	.04		
13		.34					.10	.01			1.84	.75	
14	.09	.01	.21		n		.30		.04			.15	
15	.39 n	.02	.30 n	.11	.30				.01		a .02 a	.12	
16	n .03	.10 n		.37	1.03	.01	.33	.17	.03 a		.06	.08	
17	.54						.03	.07 a	.02		.06	.19	
18					.13			a .05	.15	.18		.03	
19	.04		.07	.02		a .08 a	.41	.01	.06	.82	.01		
20	.03	.01	.06	.13			.55	.43		.66			
21	.04	.02	.07 a	.01 a			.01	1.25	.31		.10 f		
22	.38 a	.02			.05		.16	.73	.01	.11 f	.40		
23	a	.07 a	.03	.18				.39		.06	.71		
24	.02				.05	.25	.01	.30 f		f .35	.01		
25			.04			.25	.14	2.10	.64				
26	.09		.06			.23	.06 f			.17			
27					.01 f		f .01	.49		.05			
28					.21						.07 b		
29			.01 f	f		.08			.15		b .63	.50	
30	f		.19	.05		1.55	.18	.55	.08 b		.31	.11	
31			f				.07		b	.40			
Sum	2.44	2.57	1.51	0.98	2.49	2.77	7.15	9.86	4.88	5.80	5.11	6.44	

RAINFALL AT "HUSBAND'S," BARBADOES.

January 1st, to December 31st, 1867.

Days.	Jan.	Feb.	Mar	Apl.	May	June.	July.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1			.01	.02		.13	n .12	.21		.01		.02	
2	.40	.12	.17	.13	.43	n .18	.03	.11		.09		.10	
3	.16		.03	.05	.07	.05	.16	.18				1.67	
4	.03	n		n .10	n .22			.21	.06	.04	a .65	a .08	
5			.02	.10	.21	.08	.04	.03	.67	a .23	.01	.07	
6	n		n .03	.22	.01	.44	.14	.83	a .01	2.62			
7	.02			.20		.77	1.55	a .51	.50	.79			
8	.20			.03	.06	.67	a	.01	.45	.01		.93	
9						a	.12		.21	.12	.68	.09	
10		.08	.02	.04	a		.41	.02	.04	.48	.03	.05	
11	.03	.02		a		.03		.45		1.00		f .01	
12		a				.09	1.21		.17	.09	f .36		
13	a .08	.07	a			.53	2.01		.46	f	.03		
14	.16	1.20	.01	.01		.03		.13	f 1.04	.32	.97		
15	.01	.79		.08			.06	f .01	.01	2.90	.25		
16		.78	.01	.35		.05	f .12	.06	.27				
17		.01		.54	.10	f .10	.07		.06	.06		.02	
18		f .32	.07		f .03	.01	.41	.01		1.25	b	b .03	
19		.01		f .21		.06	.07	3.10	.80			.10	
20	f		f		.07	.10		.11	.01	b .16			
21	.20				.13				b .64		.08	.05	
22	.36		.14			1.94	.14	b .08	.13	.01		.34	
23	.29				.16	.01	.11		1.40			.06	
24	.01	.30				.15	b .07		1.68				
25	.38					b 1.69	.08	.59	.56			n .03	
26		.05			b .05	.67	.67	1.21	.15		n	.01	
27	b .01		.01	b .02	.01			.82	.36	n .25	.30	.06	
28	.01	b .07	b			1.20			n .04		.14	.02	
29			.01		.01	.48		n .06			.05		
30	.35				.15	1.17	.01	1.22				.03	
31	.43		.09		.09		n .28	1.24				.11	
Sum	3.13	3.82	0.62	2.10	1.80	10.63	7.88	11.20	9.72	10.43	3.55	3.88	

January 1st, to December 31st, 1868.

Days.	Jan.	Feb.	Mar	Apl.	May	June.	July.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1		a .17	a			.21	.01	.04	f 3.00	f			
2	a .13	.01				.01			.56	.18			
3	.02	.01						f .04		1.10	.04	.11	
4	.03			.05		.04	f	.03	.04				
5	.61			.01		f			.03		.37		
6		.13		.01	f		.22			.22	.10	b	
7		.01		f	.03		.03		.06	.10	b .20	.02	
8		f .11	f	.07	.08	.10	.05	.16	1.17	1.35	.02		
9	f	.16	.01	.03	.03	.04		.01	b	b	.13		
10	.10					.50	4.77	.13			1.75		
11	.14		.01				.06	b .03			.01		
12		.02					b .01				.01		
13	.01	.03	.31	.01	1.29	b	.04	.93			.01	n .22	
14	.18	.16		b	b	.05	1.24	.15		.04	n .03	.02	
15	.25	b	b				.01	.17	06	n .15			
16	.12		.03					.02	n	.09		.12	
17	b			.06			.07			.08		.04	
18	.07		.02	.01		.07		n .09	.07	.06			
19	.01			.13			n .10			.31			
20	.01					n .04	.30	.03	.15		.05	.20	
21	.17					.42			.64	.01		a .30	
22	.08	.19	.01	n .19	n	.02				.08	a		
23		n	.04		.04	.14	.20	.03	a .27	a .10			
24	n .05	.01	n .20	.15	.03	.17		a		.18		.02	
25						.17		.08	.21	.27		.04	
26						.01	a .01	.02	.22	.76			
27	.03		.02	.05		a .09	.06	.37	.72	.12			
28	.12				a	.11	.20		.02	.41	.01		
29	.13		.12	a		.63	.04	1.60	.31		f	f	
30	.12		.07		.04		.17	.01	.87			.01	
31	.71		a				.01			f		2.50	
Sum	3.09	0.96	0.89	0.77	1.54	2.82	7.60	3.94	8.40	5.61	2.76	3.60	

RAINFALL AT "HUSBAND'S," BARBADOES.

January 1st, to December 31st, 1869.

Days.	Jan.	Feb.	Mar	Apl.	May	June.	July.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1		.10	.01	.28	.02	.09		.31	3.07	1.30	.01	2.45	
2		.52	63		.03	b 1.20	b 1.05		.27	1.20			
3	.04	b .11	.01	b	b .04	.03	.08	.06		n	n		
4	.02	.11				.16	.06				.29		
5	b .03	b				.75		.24		n .22	.10		
6	.26					.02			n				
7	.07		.05		.19	.21		n					
8							.04				.01	.75	
9	.05				.09	.14	n .49	.03	.17			.34	
10			.01			n .09	.03	1.66	.02			a	
11	.06	n	.22		n	.03	.63	1.90		.18	a .01	1.23	
12	n			n	.01	.07	.11	.08	a	a .47			
13			n	.02		.02					.11	.15	
14		.17	.06			.37	.01	a .03	.07	2.60	.06	.29	
15			.04		.16	.09						.03	
16						.02	a .20			.04		.01	
17	.27					a .01			.01	.30	1.73		
18	07			.04	a .04			.07		.01	.12	f	
19	.14	a		a	.06	.12	.01	.03			f .01	.03	
20	.06	.01			.02				f 1.45	f	.02	.03	
21	a .01		a		.24	.01				.84			
22	.01	.09		.02			.19	f .01	.04	.43		.08	
23			.03		.05	.01	f .32	.35	.22	.18	1.20		
24		.03				f		1.20		.01	.03		
25	.06	.02		.04	f .46	.11		.05	.40	.11	1.20		
26		f .01	.01	f1.55	.19	.04	.10	.39		.35	b	b .02	
27	.15		f .02	.67		.06			4.56	.20		.37	
28	f .13				.06	.04			b	b 4 10		.02	
29					.16	.01	.26			.07	.01	.19	
30	.02				.20		.01	b .11		.03	.03	.01	
31					.19		b .01						
Sum	1.45	1.17	1 09	2.62	2.21	3.70	3.60	6.52	10.28	12.58	4.95	6.00	

January 1st, to December 31st, 1870.

Days.	Jan	Feb.	Mar	Apl.	May	June.	July.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1	.25	.03		n			.01		.12	a		.45	
2	n		n			.87			a 1.50	.69	.01	.05	
3	.14						.05	.01			.04		
4	.17	.01		.02	.32		.68	a .34		.02	.49		
5	.05	.23						.35	.88	.02		.16	
6						a .09	a .01	.02	2.30			.10	
7			.01			.07		.02		1.81		.01	
8	.05	a .10	.15		a	.14	.01	.24	.17		f	f	
9	a .01			a .04		.16	.07	.05	f	f .71	.45		
10	1.30	.02	a	.01		.05	1.61	.83					
11	.30		.02				.02	f				.02	
12	.39						f				.45	.32	
13	.40					f .14	.06	.25					
14	.01	.37		.19	1.20	1.38	.25	.32		.31	.09	.06	
15	.60		.09	f	f	.04	.26	.13	.11	.12		b .04	
16		f .09			.17	.27	.68			.70	b .21		
17	f .25	.01	f .04		.35		.15		.55	b .66			
18	.05	.03	.01	.18		.01		1.80	b	.60			
19	.13	.05						b .19	.15	.45		.01	
20		.16		.01	.10	b	b .16		.09	.26		.10	
21	.03	.05		.06	.31	.12			.05	.39	.12	.25	
22		b		b	b .01	.10		.70		.13	.12	n .18	
23	.11	.03			.16	.90	.19			3.00	n .27	.23	
24	b		b		.09	9.00	.28	.14		n 1.30	.59		
25	.26			.01	.07	.02	.18	3.32	n		.95		
26	.11		.01			.06	.01	n	.06		1.05		
27	.13					.01			.13		.54		
28	.01					n .06	n		.03	.03	.10		
29	.01				1.49	.10	.05	.28	.04		a .03	a .72	
30				n	n .23		.30		.01	.08	.25	.15	
31	n .02							.05		a 1.64		.74	
Sum	4.78	1.18	0.33	0.52	4.50	13.59	5 03	9.04	6 19	12.92	5.76	3.86	

RAINFALL AT "HUSBAND'S," BARBADOES.

January 1st, to December 31st, 1871.

Days.	Jan.	Feb.	Mar	Apl.	May	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1	.21	.67	.01			.17	.02		.36				
2		.03			.01		f .99	.20			.04		
3		.05		.01	.03 f	.06	.05	.01	.09		.30	.06	
4		.01	.02	.07 f			.18	.84				.40	
5	.01 f			f	.09		.07	.18			b	b	
6	f					.01	.09		b	b .02			
7			f	.01		.16	.26	.13		.17	1.26	1.11	
8						.20		b	.12		.19		
9						.39 b		3.15	.05		.20	.16	
10		.11	.51			b			.10	.02	.05		
11	.15	.05			b		.02	.07	.72	.64	1.12	.85	
12	.49 b	.06		b		.03	.02		.67	.22 n	.03 n	.24	
13	.03	.04 b				.16		1.54	1.20	.16	.24		
14	b .50						.20	.31 n		n .48		.01	
15	.19	.05					.20	.05		.05			
16	.60	.10	.09			.12		n	.33	.68	.03		
17	.20	.09					n			.50		.05	
18		.03	.71			n .11	.03		.15	.06		a .04	
19	.05 n		.01 n		n	.29	.17	.03	.40	.03 a	.03		
20	.03					.02	.01	.17	.10 a	.09	.01	.06	
21	n .40	.01 n					.08	.10 a		.01	.15	.20	
22	.08			.05		.16					.08	21	
23	.02	.09				.01		a .09		.83			
24	.12	.05	.35		.78	.20		.05		.15	.16		
25	.04	.01	.05		.02 a		a	.11		.21	.02		
26	.69		.02		.02	.11	.02	.03	.11		.24 f		
27	.05 a			a	a		.65	1.47		f			
28	a .32	.06			.35	.01	.02		f .07 f				
29			a					.41	.17			.01	
30	.11					.15		f .45	.17	.18	.38		
31	.05				.03		f .01	.21		.03			
Sum	4.34	1.51	1.77	0.14	1.33	2.36	3.09	9.60	4.81	4.53	4.53	3.43	

January 1st, to December 31st, 1872.

Days.	Jan.	Feb.	Mar	Apl.	May	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1				b	.02	.09					n .05		
2		b	b					.02		n	.15	.05	
3	b							.14 n		.32		.32	
4	.16	.62					.27 n		.06	.10		.02	
5	.04	.18			.05	.01 n					.73	.08	
6	.11	.32				n .35	.18		.03	.11	.40		
7		.04			n .35	.24			.04			a .02	
8		.07		n			.07	42	.39	.51 a	.14		
9		n	n				.16		2.08 a			.05	
10	n .36	.70				.01		.01 a		.27	.63		
11		.02							.01	.68	.25		
12	.05	.01		.02		.01		a .30	.01	.03	1.50		
13		1.05	.05	.01			a	.09			1.10	.01	
14		.15			.27 a	.14		.09			.14 f		
15			.05 a		a .02			.04		.15 f			
16		a					.03	.24	.01 f				
17	a		a .03			.32		.12 f		.01	.05		
18	.18						.38 f	.16	.07		.40		
19	.02		.02			.05	.11	.08			1.74	.03	
20	.02		.07			.06 f	05		.02		.14		
21	.02			.07		f 1.60		.03	.07		.05	.31	
22			.17		f	.05		.13	.02		.05	.04	
23	.05		.22 f								b .15	b .14	
24		f	.15						b	b	.36	.05	
25	f		f .01					b	.20	.35	.10	.26	
26			.01		.37	1.20		.05	.01	1.05	.15	.16	
27					.05 b		b .01	.05	.16		.17	.11	
28	.03					.10			.07		.01	.16	
29					b			.05				.41	
30				b	.47					.20 n		n 2.63	
31					.23		.19	.01		.13		.13	
Sum	1.04	3.16	0.78	0.10	1.83	4.23	1.45	2.03	3.25	3.91	8.46	4.98	

RAINFALL AT "HUSBAND'S," BARBADOES.

January 1st, to December 31st, 1873.

Days.	Jan.	Feb.	Mar.	Apl.	May	June.	July.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1					.72		.11 a				.61		
2	.01	.01		.03	.06	a			.05	1.20	.65		
3	.05	.01				a .03	.03	1.26					
4	.12	a .31		a .07	a			.52	.01	.62 f		f .07	
5	a .01	.03					.26		.06	.59	.08	.06	
6	.71	.09	a .07				2.73		f	f		.54	
7	.11	.10	.15			.02		.91				.25	
8	.05	.05					.10 f		.05	.54		.14	
9	.80		.03				.15		1.28			.12	
10	.09					f .05 f		.68	3.09	.20		.04	
11				.13	.06			.75	4.80	.27		b	
12		f		f1.00 f		.05	.07			1.20 b		.04	
13	f	.54					.22		b	b			
14	.06	.16 f									.05		
15	.14					.05		b	.18	6.30			
16		.02			.14	.05	.15	.02	1.11			.01	
17	.01					b	b .50	.08	.02			.37	
18	.11		.03				.11		.03				
19	.15		.02		b .07	.15	.03		.07		.10 n	.06	
20		b		b					.17	.09 n			
21	b		b					.11 n	.03 n				
22						.27	.08	.46	2.20	.13	.02	.05	
23	.73			.01		.04	.50 n	.32		.76			
24	.03					n	.14		.02	.33			
25	.04		.01		.20		n	.11		.21		.11	
26	.20			n	n .07			.30		.23	.10 a	.06	
27	.03 n		.06		.25		.15			a	.03		
28	n		n		.25			.01		.28			
29						.08		.10 a	.05 a	.02	.03	.17	
30					.06	.01		1 20		.24		.01	
31	.10						a	.20	.18	1.08		.05	
Sum	3.55	1.32	0.37	1.24	1.88	0.08	5.41	7.03	13.35	14.29	1.67	2.15	

REPLY TO DR. T. STERRY HUNT.

By F. A. Genth.

(*Read before the American Philosophical Society, July* 17, 1874.)

Dr. T. Sterry Hunt has published in the Proceedings of the Boston Society of Natural History, Vol. XVI., March 4th, 1874, an article, entitled: "*On Dr. Genth's Researches on Corundum and its associated minerals,*" in which he charges me—*in common with many others*—of having *fallen into errors* and of having been *led to conclusions wholly untenable,* for a *lack of a clear understanding as to replacement, alteration and association in the mineral kingdom.*

He then gives an outline of the manner in which the various alterations in a mineral species may take place, by replacement, envelopment and epigenesis with examples for each, and dwells at more length upon the fallacy of considering the alterations of many minerals and rock masses as the *result of an epigenic process; a doctrine which has been embodied in the dictum of Prof. Dana*: "*regional metamorphism is pseudomorphism on a broad scale.*"

He then refers briefly to the results of my investigation on corundum, in which I have shown that by "epigenic" pseudomorphism this mineral has been altered into numerous more complex species and rock masses—and winds up by stating that he *not only has carefully studied*

my paper, but had also *examined the extensive collection of specimens upon which my conclusions were based*, and that—*all the phenomena in question are nothing more than examples of association and envelopment, and that the corundum-bearing veins had their parallels in the granitic veins with beryl and tourmaline in the White Mountain rocks, and the calcareous veinstones with apatite, pyroxene, phlogopite and graphite of the Laurentian rocks.*

I may be permitted to say a few words in reply to Dr. Hunt's assertion, that I had fallen into errors and had been led to wholly untenable conclusions.

When I had the good fortune to obtain a few years ago the *first real* pseudomorph after corundum—the spinel from India, and afterwards brought together numerous specimens of analogous alterations, showing from the *same* locality crystals of corundum without any, and others representing all stages of alteration from a thin coating to the complete disappearance of every vestige of corundum, and when I proved that such changes have resulted in the conversion of corundum into about two dozen mineral species; I could not understand how any unprejudiced mind could arrive at any other conclusions, but that these extraordinary occurrences which I have described, were the result of epigenic pseudomorphism.

This opinion has been adopted almost without exception by all who have had an opportunity to examine my specimens, or who have studied my paper. If Dr. Hunt differs from me, I certainly will not deny to him the right to believe what suits his own notions, but when he boldly charges me with having committed errors, I want better proofs than a repetition of his views, with which we were familiar long ago. He certainly has not a single fact which could show the fallacy of my conclusions, or he would have produced it.

The corundum alterations have nothing in common with the Fontainebleau crystals, or with stanniferous orthoclase; the green and red tourmalines from Paris, Me., or the beryls filled with orthoclase, or the zircon and galenite filled with calcite, and cannot be explained *rationally* as examples of *association* and *envelopment*.

To give strength to his statements, however, Dr. Hunt says that he had "*examined*" with me "*the extensive collection of specimens upon which my conclusions were based.*" When Dr. Hunt favored me with a visit, I was in hope that he *would examine* my specimens, but his time was so short that he saw only about one-third of them, and the "*examination*" (*!?*) of these was finished in about *five minutes*.

As to his last sentence, I must confess that I am unable to discover the least parallelism between the corundum-bearing veins and the granitic veins, with beryl and tourmaline, so common in the White Mountains, and the calcareous veinstones with apatite, pyroxene, phlogopite and graphite of the Laurentian rocks;—but can see in the former nothing but

the product of a partial, and in many instances of a pretty thorough alteration of the original corundum into micaceous and chloritic schists or beds, or, as Prof. Dana would express it: "*a pseudomorphism on a broad scale.*"

UNIVERSITY OF PENNSYLVANIA, July 4th, 1874.

CONTRIBUTIONS FROM THE LABORATORY OF THE UNIVERSITY OF PENNSYLVANIA.

NO. II.

ON AN IMPROVEMENT OF THE BURETTE VALVE.

BY GEO. A. KOENIG, PH.D.

(*Read before the American Philosophical Society, August* 21, 1874).

Strictest simplicity of construction must be considered as the first requirement of any tool or apparatus, besides fitness for all work within its sphere of action. Frequently we meet with constructions in which fitness has been sacrificed to a considerable extent for the sake of simplicity, and quite as often the reverse. There are cases, indeed, in which circumstances demand even a certain degree of one-sidedness, but in my judgment a more complicated apparatus, overcoming defects of working attached to a simpler device, is practically the more desirable of the two.

When Frederick Mohr gave his rubber tube valve to volumetric analysis, he had indeed hit, like a true genius, upon the simplest contrivance imaginable. To this piece of apparatus must be ascribed the rapid adoption of volumetrical determinations by analytical chemistry. No matter how simple the volumetrical reactions might be, if they had to be executed by an unhandy manipulation, the practical chemist would rather keep on with his accustomed precipitations and weighings.

Let us consider now the conditions under which the burette will satisfy all demands which can be made upon it.

1. *The instrument must not engage the hands of the operator during the operation.*

This condition requires the burette to be fixed and its position to be quite independent from the person of the manipulator.

2. *The instrument must allow a rapid discharge of its liquid contents to any desired volume, without the application of another force than that of gravitation.*

This condition requires the tube to be fixed vertically and to be furnished with a valve.

3. *The valve must allow to interrupt the current instantaneously and completely, and also the regulation of the liquid current from the smallest drop to a full stream.*

4. *The working of the valve must be easy, not require any effort on the*

part of the operator, by which the latter's attention is necessarily detracted from the observation of the reaction.

5. *The apparatus must not come out of order easily under ordinary circumstances and attentive manipulation.*

6. *The instrument must be applicable to all solutions used in volumetric determinations.*

The present forms of the burette are of two types : a, the *dropping burette*, which in its simplest form is a graduated, lipped glass vessel, from which the solution is poured out by the lip.

Gay-Lussac improved this primitive instrument by the appendage of a capilar tube, which although preventing a sudden stream, when but a drop is wanted, still does not come up with the above given conditions except the last, and is altogether an unhandy piece of apparatus.

b, *The valve burette.* The very imperfect instrument just mentioned stimulated invention, and we find as the next step the graduated tube fixed to a stand vertically, and furnished with a glass ground perforated stop-cock. This instrument is very nearly perfect. if well executed, but from the nature of things it cannot fill the conditions 4 and 5. The rough surface produced by grinding is exceedingly disposed to capilar action and soon the effects from this show themselves by a layer of crystals cementing the cock completely. These working defects are, however, so well known, that I need hardly dwell any longer upon them. The same applies to Geissler's glass-rod stopper.

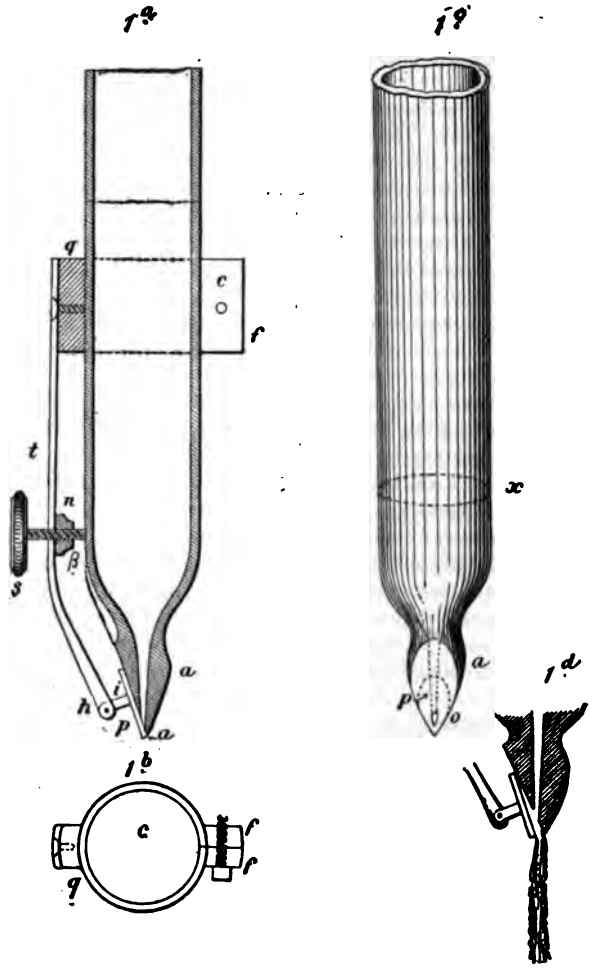
Then, Mohr showed how simply these difficulties could be overcome by connecting the neck of the tube and the mouth with a piece of India rubber tube pressed together by a spring clamp, or pinch cork. Comparing this device with the 6 conditions, we find, after a long practice, that it is far from being satisfactory. If the spring is strong it requires a remarkable muscular exertion to open it, besides destroying the elasticity of the rubber ; if weak, it will not close the valve completely. I find, moreover, that the rubber tube becomes soon deteriorated chemically, especially by alkaline solutions, and that many volumetric solutions cannot be brought into contact with such a large surface of rubber without undergoing a change in their docimastical value. The substitution of Hoffmann's screw clamp for the spring clamp is not so very happy ; it requires both hands for the adjustment just in the moment when one hand is most needed for stirring the liquid, besides it acts too slowly, several turns of the screw being needed to overcome the elasticity of the comparatively thick rubber tubing.

J. Blodget Britton described an apparatus (Journal of the Franklin Institute, 1870,) which is undoubtedly a considerable step forward. He recognized that the valve had to be placed externally, and that it had to possess a screw movement. He draws his burette at the lower end into a capilar tube, bends it slightly, so as to bring the orifice in contact with a cork plate, which itself is fastened to a steel spring, opened by a screw bolt. To prevent splashing, the opening must be very narrow, and con-

sequently the emptying of the burette requires a considerable extent of time. But otherwise the apparatus is quite perfect and neat in its execution.

I shall proceed now with the description of a device, which has realized my expectations as to the possibility of combining the advantages of Mohr's principle with universal applicability and convenience of handling.

1, *The burette.* I take a Mohr burette tube, as it is furnished by the

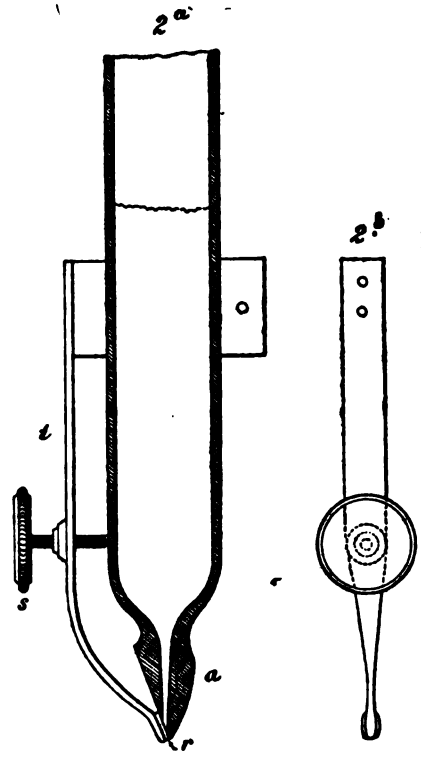


trade, hold the inflated part of the neck (serving for a hold to the rubber) over a Bunsen flame and let it contract slowly at a dull-red heat, until the channel has become capilar as shown in figures 1a, 1c and 2a of the accompanying plate. It needs hardly to be remarked, that during the process, the tube has to be kept revolving, and allowed to cool slowly. The glass wall has become very thick and strong, facilitating the next process of grinding. This is done upon an ordinary rotary grindstone in from 8 to 10 minutes. I grind off one-half of the inflation at a steep angle, as shown in the figures. The orifice is not required to have a definite size and is naturally given by the points α, β. The grinding is continued until the elliptic section of the channel has come with its lowest point from about 1-16 to 1-8 of an inch above the lowest point of the inclined ground plane.

A very short practice affords sufficient skill to grind a very nearly plane surface. Absolute planeity is not required. The sides and back are ground next to produce a point, which is necessary for the letting out of small drops of liquid. The ground face stands at right angles to the graduation and may be put either on the right or on the left side, according to the convenience of the operator. Fig. 1c represents a front view of the ground face, with the capilar orifice at 0. The size of the latter depends on the kind of work which is to be done with the burette, as it influences the size of a drop. On my 20cc burette, divided into twentieths, I have a very narrow orifice, a drop corresponding to one-half a division. I use this burette exclusively for argentum nitrate solution. For ordinary alkalimetric work I use a burette (50cc) graduated into one-fifths and allow the drops to equal one-tenth cubic in. This opening empties the burette in one minute and a quarter, when running at full stream.

2, *The valve.* Platinum in form of a smooth plate is not acted upon materially by any of the solutions now in use for volumetrical analysis. The valve consists of a platinum plate *p* of elliptical shape, $\frac{3}{8}$ and 3-16 of an inch being the respective parameters. Thickness about 1-32 of an inch. To the centre of this plate is soldered the platinum stem i, the end of which is pierced by an eye. The spring t, made of brass or German silver and platinated, is screwed to the clamp c, and has a fork at its other end for the insertion of the platinum stem i, forming thus the hinge h. It carries a nut n, through which the screw s passes. In order to open the valve, the screw head is turned, when the screw bolt comes into contact with the glass tube and forces the spring backwards. The valve plate assumes then a position as represented in figure 1*d*, allowing the full stream to run straight downwards without the least splashing. The capilar orifice being elliptical, with its long axis parallel to the stream, it is evident that by reversing the screw, the orifice will close gradually, the lowest point the last, allowing a most complete regulation, and when once reduced to dropping a quarter of a turn of the screw will close totally. The only objection to this arrangement of the valve, which has presented

itself thus far, is the delicacy of the hinge. Yet I have had one in use constantly for six months past, and it works as satisfactorily as on the first day. In the hands of beginners it may come out of order sooner. The clamp *c* is made of brass tubing, with the flanges *f f* and the block *g* sol-



dered on. It is made sufficiently large to admit of variation in the diameter of the burette tubes, a strip of paper being used as a filling. The delicacy of the hinge, and to some extent the cost of the apparatus ($2.50) have prompted me to substitute a simpler construction.

Figures 2*a* and 2*b* represent this device.

The platinum plate is replaced by a piece of pure rubber sheeting, the thickness of strong paper ⅛ by 3-16 of an inch, which is attached to the end of the spring by means of a solution of rubber. The lower part of the spring may be rendered proof against chemical action by galvanic platinum plating, or by a coating of rubber. The former is certainly the best, but I found by several months' experience, that a spring coated

with rubber, will resist the action of standard acids, and shows no sign of oxydation and dissolution. The rubber coating is done very quickly with a concentrated chloroformic solution. The dipping in and drying is repeated several times. I have furnished now all the burettes used by my students with this simpler contrivance ($1.00) and have found my expectations more than realized. The surface of contact between the rubber and the standard solutions is so small, that a deteriorating influence on the latter could not be noticed.

I must acknowledge my obligation to Mr. J. Zentmayer, the well-known optician and mechanician, of this city, for the practical execution of my ideas and for many valuable suggestions in the course of my experiments. Any further information that may be deemed necessary shall most gladly be given.

CONTRIBUTIONS FROM THE LABORATORY OF THE UNIVERSITY OF PENNSYLVANIA.

No. III.

ON AMERICAN TELLURIUM AND BISMUTH MINERALS.

By F. A. Genth.

(*Read before the American Philosophical Society, August* 21*st*, 1874.)

On several occasions I have given descriptions and analyses of tellurium minerals, which have been found associated with the gold ores of this country. Since my last paper on this subject (Amer. Journ. of Science [2] XLV., 306–319) several highly interesting discoveries have been made, which not only augment the list of species, but also corroborate some of my former observations.

Most important is the occurrence of the tellurium ores at the Red Cloud Mine, near Goldhill, in Boulder County, Colorado. Prof. B. Silliman (Journ. of Science [3] VIII. 25–33), has given a very accurate and careful description of some of the minerals found at this locality, and an exceedingly interesting account of the geological position of the vein.

Through the liberality of my friend J. F. L. Schirmer, Esq., Superintendent of the United States Mint at Denver, Colorado, I have been put in possession of a considerable quantity of very pure and excellent material for investigation, including several varieties not mentioned by Prof. Silliman.

Another interesting locality of tellurium minerals is the Briggs or King's Mountain Gold Mine, sometimes called the Gaston Mine, in Gaston Co., N. C., where I noted this occurrence about two years ago.

A third one is in the neighborhood of Highland, Montana. Several others of minor importance will be mentioned under the different species.

The following are the results of my investigations:

1. Native Tellurium.

The occurrence at the Red Cloud Mine is fully described by Prof. Silliman. I have observed it on several specimens in small, very indistinct crystals, with rounded edges; also in one splendid cleavage piece, show- a plate of $\frac{3}{8}$ of an inch in length, and nearly $\frac{1}{2}$ of an inch in width, from which I have obtained a hexagonal cleavage crystal of $\frac{5}{16}$ of an inch in length, and $\frac{1}{4}$ of an inch in thickness. Generally it is disseminated in fine grains through quartz, cleavage perfect, color tin-white, inclining to gray.

Associated with sylvanite, altaite and pyrite.

Without destroying my best specimens, I could not get enough of pure material for analysis.

2. Tetradymite.

The sulphurous variety of tetradymite has been observed at several new localities: associated with gold ores in small lead-colored scales at Spaulding Co., Georgia; also in York District, S. C.; in quartz from the gravel deposits of Burke and McDowell Counties, N. C.; in gray quartz with gold at the Montgomery Mine, Hassayampa District, Arizona; and at the "Uncle Sam's Lode," in Highland District, Montana. At the latter place it is found associated both with quartz and gold, and in dolomite. Part of it is oxydized into montanite. The latter, however, is not in a state of sufficient purity for analysis. That the tellurium is present as telluric acid, and not as tellurous acid, is proved by the large evolution of chlorine, when it is heated with chlorhydric acid.*

The tetradymite occurs here in considerable quantity, in foliated masses with foliæ sometimes $\frac{3}{4}$ of an inch in width and scaly-granular. Its color is between lead-gray and iron-black. It is often tarnished with pavonine colors.

The gold, which is often interlaminated with it, shows the striation of the tetradymite, and is evidently the result of its precipitating action upon the gold in solution, in the same manner as already stated in my notice of the pseudomorphous gold after tetradymite from the White Hall Mine (Amer. Journ. of Science [2] XXVIII., 254).

It is an interesting fact that the tetradymite from Uncle Sam's Lode contains sulphur as an essential constituent, while that from the gold placers of Highland, which I had received from Mr. Kleinschmidt, and described in the Journal of Science [2] XLV., 316, is *free* from it.

My friend Mr. P. Knabe has made some very important observations on this subject, which are contained in his letter, dated Highland, Mon-

* I notice the following misprints in Dr. Burkart's paper, "Uber das Vorkommen verschiedener Tellur-Minerale in den Vereinigten Staaten von Nord-Amerika," Leonhard & Geinitz Neues Jahrbuch der Mineralogie, etc., 1873, page 491, line 5 from bottom: *Tellursæure* instead of *Tellurige Sæure*, and on page 492, line 15, *Tellurige Sæure* instead of *Tellursæure*.

tana, Dec. 26th, 1870, of which I translate that part which refers to this subject. He says:

"*I have discovered the tetradymite which I sent you in* Uncle Sam's Lode, *in Highland District. Two years ago I examined a fragment of tetradymite from Highland Gulch, which I found to be the* sulphurous *variety, and was therefore very much surprised to find from your pamphlet that the tetradymite from Highland Gulch examined by you was the variety* without *sulphur. After I had repeatedly examined pieces of the said mineral, I made the discovery that* both varieties *of* tetradymite *are found together in Highland Gulch. This was the more interesting, since there occur in it also two different varieties of gold,* which *fact gives pretty conclusive evidence that the gold of the Gulch comes from* two different *formations. The finest gold of the Gulch originates undoubtedly from the garnet which occurs between the dolomite and granite. I then examined the different trial pits in the dolomite, and found in this formation at the head of the Gulch in the Uncle Sam Lode the specimens which I sent you. In the garnet rock which adjoins the Gulch on its left side, I have not yet found any tetradymite; but in a piece of garnet from the Gulch I found* gold *and* tetradymite without *sulphur. In all the samples of the sulphurous variety of tetradymite from the Gulch, as well as in that from Uncle Sam's Lode, I found a trace of selenium.*"

The following are the results of my analyses of the tetradymite from Uncle Sam's Lode:

		Broadly foliated.		Smaller scales from dolomite.
Sp. Gr.	=	7.332	—	7.542
Quartz	=	0.05	—	0.58
Gold	=	0.21	—	——
Bismuth	=	60.49	—	59.24
Copper	=	trace	—	0.47
Iron	=	0.09	—	——
Tellurium (by diff.)	=	34.90	— (by diff.)	34.41
Selenium	=	trace	—	0.14
Sulphur	=	4.26	—	15.16
		100.00		100.00

At the Red Cloud Mine, Colorado, tetradymite seems to be one of the rarest minerals. The first indication which I had of it was the observation of a small quantity of bismuth in the analysis of one of the varieties of petzite. After a great deal of search I discovered, associated with pyrite and auriferous hessite, a very few minute iron-gray scales, some of them with a bluish tarnish, which on examination proved to be the *sulphurous* variety of tetradymite.

3. Altaite.

I have discovered this rare mineral at *two* new localities—the Red Cloud Mine, Colorado, and the King's Mountain Mine, Gaston Co., N. C.

At the latter locality it is found in sugary quartz associated with gold, galenite, chalcopyrite, pyrite, antimonial tetrahedrite, and more rarely with nagyagite and a greenish micaceous mineral resembling fuchsite. It occurs in small quantities only, and is so much mixed with the other minerals, that I was unable to select enough for a quantitative analysis. It is easily recognized by its tin-white color, with the greenish-yellow hue, and its great lustre. It is found in particles showing the distinct cubical cleavage, but also finely granular. A very interesting but quite small piece shows a cleavage mass, part of which is altaite, part galenite, without any interruption in the cleavage plane, both minerals being easily distinguishable by their color.

The altaite at the Red Cloud Mine, Colorado, is found in larger masses, generally, however, very much intermixed with other minerals, especially native tellurium and sylvanite. It is associated with pyrite, siderite and quartz. Sometimes it is found in indistinct cubical crystals, apparently coated with a thin film of galenite; rarely in larger cleavage masses. I have a cleavage cube of ⅜ of an inch in size of distinct cleavage: some of the planes are slightly coated with galenite. The most frequent occurrence is that in granular masses with indistinct cubical cleavage, a fracture inclining to subconchoidal and a yellowish tarnish.*

The analysis of a portion of the cleavage cube gave the following results:

Spec. Gr.	=	8.060		
Quartz	=	0.19	—	0.32
Gold	=	0.19	—	0.16
Silver	=	0.62	—	0.79
Copper	=	0.06	—	0.06
Lead	=	60.22	—	60.53
Zinc	=	0.15	—	0.04
Iron	=	0.48	—	0.33
Tellurium	=	37.99	—	37.51
		99.90		99.74

4. Hessite, Auriferous Hessite, Petzite.

Varieties of telluride of silver with variable quantities of gold are the principal minerals which give the ores of the Red Cloud Mine their value. I believe that I was the first to whom specimens of the rich auriferous variety were sent by Mr. Schirmer. These I have determined as petzite. Prof. Silliman mentions a variety (l. c.) containing 7.131 per cent. of gold and 51.061 per cent. of silver, of which he gives a very accurate description; he evidently had only this *one*, and therefore comes to the conclusion that the Red Cloud Mine contained *no* other varieties. It will be

* In Dr. Burkart's paper (l. c.) p. 487, line 12 from the bottom, read: *hexaëdrische* instead of *hexagonale*.

seen from the analyses which I give below, that there are several, from almost pure hessite without gold, up to the highly auriferous of the same composition as that from the Stanislaus and Golden Rule Mines in California.

a. HESSITE.

The pure hessite appears to be very rare. I have received only one small piece, which Mr. Schirmer distinguished as "black tellurium." It is of a dark iron-gray color, inclining to black, granular structure and uneven fracture; powder dark lead-gray; sectile. Its spec. gr. = 8.178.

It contains some cavities lined with minute crystals of pyrite and barite.

The analyses gave:

Gold	=	0.22	—	0.20
Silver	=	59.91	—	60.19
Copper	=	0.17	—	0.16
Lead	=	0.45	—	0.18
Zinc	=	trace	—	trace
Iron	=	1.35	—	1.20
Tellurium	=	37.86	by diff. =	38.07
		99.96		100.00

In all the other varieties, the difference in the appearance of the mineral is so slight that it is almost impossible to distinguish them. They all have an iron-gray color, and frequently assume by tarnishing a darker or purplish color, a subconchoidal fracture; the more argentiferous are somewhat darker, the more auriferous lighter and more brittle.

b. AURIFEROUS HESSITES.

		α, Sp. gr. = 8.789.				*β*, Sp. gr. = 8.897.
Quartz	=	0.18	—	0.13	—	0.70
Gold	=	3.31	—	3.34	—	13.09
Silver	=	59.68	—	59.83	—	50.56
Copper	=	0.05	—	0.06	—	0.07
Lead	=	——	—	——	—	0.17
Zinc	=	——	—	——	—	0.15
Iron	=	0.15	—	0.21	—	0.36
Tellurium	=	37.60	—	36.74	—	34.91
		100.97	—	100.31		100.01

c. PETZITE.

		α		*β*
Sp. Gr.	=	9.010	—	9.020
Quartz	=	0.62	—	0.05
Gold	=	24.10	—	24.69
Silver	=	40.73	—	40.80

Copper	=	trace	—	trace
Bismuth	=	0.41	—	——
Lead	=	0.26	—	——
Zinc	=	0.05	—	0.21
Iron	=	0.78	—	1.28
Tellurium	=	33.49	by diff.	32.97
		100.44		100.00

The above analyses, to which add for comparison those of Prof. Silliman and the petzite from Nagy-Ag, give the following atomic ratios between gold, silver and tellurium:

b α	=	1	:	32.7	:	34.3
Silliman	=	1	:	14	:	——
b β	=	1	:	7	:	8.2
Nagy-Ag	=	1	:	4.7	:	5.9
Petzite	=	1	:	3.1	:	4.2

From which it will be seen that gold and silver appear to replace each other in indefinite proportions, while the mixture of the two combines atom for atom with tellurium.

5. Sylvanite.

The Red Cloud Mine is the first American locality at which this mineral has been found. It was observed by Prof. Silliman, but his stock was not sufficient for a more minute description. The specimens which I have are massive, showing eminent cleavage in one direction, giving it a plated appearance. In one piece it occurs in quartz, which is penetrated by crystalline aggregations arranged in a line of over one inch in length and $\frac{1}{32}$ of an inch in thickness, resembling the real "*graphic tellurium*" from Transylvania. Its color is silver-white, with a strong gray tint; brilliant metallic lustre.

It is associated with pyrite, which, in very small crystals, is often so thickly disseminated through the mass, that it is very difficult, if not impossible, to obtain pure material for analysis.

Sp. gr. = 7.943.

		α		β		γ
Quartz	=	0.32	—	0.86	—	0.59
Gold	=	24.83	—	23.06	—	25.67
Silver	=	13.05	—	11.52	—	11.92
Copper	=	0.23	—	0.57	—	0.21
Lead	=	——	—	——	—	0.46
Zinc	=	0.45	—	0.11	—	0.06
Iron	=	3.28	—	4.84	—	1.17
Tellurium	=	56.31	—	54.60	— by diff. =	58.87
Selenium	=	trace	—	trace	—	trace
Sulphur	=	1.82	— by diff. =	4.44	—	1.05
		100.29		100.00		100.00

The atomic ratios between gold, silver and tellurium, and the combined gold and silver and tellurium are as follows :

α Au : Ag : Te = 1 : 0.96 : 6.98 — (Au Ag) : Te = 1 : 3.6
β " : " : " = 1 : 0.91 : 7.29 — " : " = 1 : 3.8
γ " : " : " = 1 : 0.84 : 6.45 — " : " = 1 : 3.5

6. Calaverite.

I have observed one very minute specimen of this rare mineral amongst those from the Red Cloud Mine, which Mr. Schirmer sent me. It fully answers the description which I have previously given (l. c.).

It is associated with sylvanite and quartz. It contains a somewhat smaller percentage of silver than that from the Stanislaus Mine in California.

The scarcity of the material did not allow me to obtain for analysis more than 0.1654 grs., from which 0.0050 grs. of quartz were deducted. Dr. G. A. Koenig reduced 0.0332 grs. before the blowpipe, and obtained 42.32 per cent. of gold and silver, which I then separated with the results given below.

It contains :

Gold	=	40.59	—	39.76	42.32
Silver	=	2.24	—	2.56	
Tellurium	=	57.67	— by diff.	= 57.68	
Copper and iron	=	traces		—	
		100.50		100.00	

I was in the hope that I would find in the oxydized specimens of the tellurium ores from the Red Cloud Mine interesting products of decomposition, but observed hardly anything else than native gold, sometimes in very minute scales in the partly decomposed petzite, and small quanties of cerargyrite. There is also a minute quantity of what is probably tellurate of silver present, because if the oxydized minerals be treated with ammonic hydrate, and the ammonic solution be filtered and boiled, and subsequently acidulated with nitric acid, the argentic chloride be precipitated, the filtrate from this contains both *silver* and *tellurium*.

I also observed among the oxydized pieces, one which had a yellowish coating, probably montanite ; the quantity, however, was too small for any investigation other than a determination of the presence of bismuth and tellurium.

7. Tellurate of Copper and Lead—a new mineral.

This new tellurate has been discovered by Mr. P. Knabe, in the "Iron Rod" Mine, Silver Star District, Montana. He had sent me a small quantity of the same, which consisted of an apparently uniform siskin-green powder.

I had intended to make a full investigation of the same, but unfortunately it has been mislaid or lost.

However, I will give the most important part of the information about its occurrence, which I have received in Mr. Knabe's letter, dated Highland, March 26th, 1871.

"*I send you enclosed a mineral from the Iron Rod Mine, Silver Star District, Montana, which I hope will be interesting to you. The same substance apparently is found in the Silver Star District in all the veins which occur in the crystalline states. I have not examined that from the Iron Rod Mine, because I did not want to use up a portion of the already small quantity—but in a mineral of exactly the same appearance from the "Green Campbell" Mine, in the same District, I have found oxides of copper and lead and telluric acid. I shall try to obtain it from different mines in order to ascertain whether it is constant in its composition or is a mixture. In the Green Campbell Mine it is found as a thin coating upon the selvage of the footwall, whilst in the Iron Rod Mine it occurs in the fissures of the rock.*"

In the same letter Mr. Knabe mentions the interesting fact of having examined a graphite from the Harvey Lode, occurring in the dolomite, which contains 2.1 per cent. of silver.

This is the last information which I have received from Mr. K.; in it he states that in the latter part of May, 1871, he would make explorations in the wilderness, 40 miles W. of Highland.

8. Bismuthinite.

Dr. Burkart states in an appendix to his observations (l. c.) on the American Tellurium Minerals, (Leonhard & Geinitz Neues Jahrbuch, etc., 1874, 9,) that in the Las Animas Mine on the Sugar Loaf Mountain, Colorado, bismuth ores are found—either native, or in combination with sulphur and tellurium.

The few small pieces of bismuth ores which I have seen from this locality were bismuthinite, in stout columnar aggregations, in great part converted into bismuthite, but with still a large percentage of undecomposed tersulphide.

It contained a small percentage of silver, but not *a trace of tellurium.*

9. Schirmerite—a new mineral.

Massive, finely granular, disseminated through quartz; no cleavage could be observed; fracture uneven; soft, brittle. Sp. G. = 6.737; lead-gray inclining to iron-black, lustre metallic. B. B. fuses very easily and gives the reactions of bismuth, lead, silver and sulphur.

After deducting 1.00 per cent. quartz in analysis I., and 1.07 per cent. in II., the results are as follows:

		I.		II.
Lead	=	12.69		12.76
Silver	=	22.82		24.75
Bismuth	=	46.91	by diff.	47.27
Zinc	=	0.08		0.13
Iron	=	0.03		0.07
Sulphur	=	14.41		15.02
		96.94		100.00

The atomic ratios of Pb : Ag : Bi : S are very nearly = 1 : 4 : 4 : 9, corresponding with the composition : PbS, 2 Ag_2S, 2 Bi_2S_3, which gives

Pb	=	11.71
Ag	=	24.45
Bi	=	47.54
S	=	16.30
		100.00

It is allied to and closely resembles cosalite.

Dedicated to J. F. L. Schirmer, Esq.

P.S. Since the reading of my paper an article has appeared in the Engineering and Mining Journal, of August 29th, 1874, on "Tellurium Ores of Colorado, by Fred. M. Endlich," which I must not pass unnoticed, as it contains several statements which I cannot endorse.

The paper shows that Dr. Endlich had not a sufficient quantity of pure material for his examinations, and therefore based his new species upon a partial examination of mixtures.

His "*Schirmerite*" is evidently nothing else but a mixture of petzite, either with pyrite or perhaps with a telluride of iron—a mineral which has not yet been found in its *pure* state, the existence of which, however, is probable from the fact that both the true and the auriferous hessites, which are quite *free* from sulphur, invariably contain a minute quantity of iron—which according to my analyses varies from 0.15 to 1.35 per cent.

If Dr. Endlich had given his name to a good species, I would very cheerfully have adopted it and given another to my new sulphbismuthide of silver and lead—but as the mixture which he describes is not entitled to a name, that of "Schirmerite" must remain for my species.

His "*Henryite*" is undoubtedly nothing but an altaite, with an admixture of pyrite.

Knowing from Mr. Schirmer, that he has given me for this investigation the purest and best of *all* the minerals which have occurred at the Red Cloud Mine, I can state without hesitation that Dr. Endlich's species have no existence.

ON THE RESOURCES, PRODUCTIONS AND SOCIAL CONDITION OF EGYPT.

By Alexander Delmar,

Late Director of the United States Bureau of Statistics.

(*Read before the American Philosophical Society, October* 2, 1874.)

Introduction.

The United States of America produce annually about 275 million bushels of wheat, or about 6½ bushels per capita of population. Of this amount, they consume over 230 million bushels, or about 5½ bushels per capita; and have about 42 million bushels surplus left for sale.

The United Kingdom of Great Britain and Ireland produces annually about 95 million bushels of wheat and consumes 190 million bushels, or about 5¾ bushels per capita. It has therefore a deficit to purchase, amounting to as much, of wheat, as all it produces, or 95 million bushels. Thus, England has two bushels of wheat to buy where we have one to sell.

As wheat forms the daily bread of the two countries, and, unless in exceptional or extreme cases, no substitute for it will be accepted by the people, the purchases of these vast quantities of wheat on the one side, and their sale on the other, form, naturally enough, occasions for the exercise of a good deal of what may be euphemized as commercial diplomacy. In plain English the grain trade abounds with misrepresentation, and, as it happens, at the present time, this misrepresentation has, to a certain extent, centred itself upon the agricultural resources and wheat crop of Egypt.

Treating, as it will pretty fully, upon this topic, the present paper therefore claims to possess something more of scientific value than one which might have related less directly to the affairs of our everyday life; and although this claim might pass for nothing among peoples whose lives and thoughts are more in the remote past or remote future, than the present, I trust that it does not imply too great assurance if I venture to hope that, if made good, it will lose nothing at the hands of my own countrymen, on account of this utilitarian basis.

The gist of the present dispute about Egypt is as follows: A school of British agricultural writers at the head of whom is Mr. Kains-Jackson, estimates that during the ensuing harvest year 1874-5, the United Kingdom, instead of needing to purchase, as usual, about 95 million bushels of wheat, will require but 64 to 72 million bushels; and, on the other hand, instead of having to rely, as usual, mainly upon the United States, has by reason of the present year's abundant wheat harvest throughout the civilized world, the option of purchasing as much wheat—perhaps more—elsewhere, as she will need to purchase from us.

Among the countries specified by this authority, as having this year a surplus of wheat to dispose of, are France, Germany, Russia and Turkey.

Mr. Kains-Jackson's statements with regard to the wheat crops of all of these countries, as well with regard to that of his own country, have already been shown to be excessive; while as to Turkey, he was reminded that, so far from possessing a surplus crop of wheat, the people in Anatolia were dying from starvation, literally in myriads. To this, the response has been made that by Turkey was meant Egypt, and as none of the writers upon the subject appeared to know anything more about Egypt than that it was a land of pyramids, ruined temples and "backsheesh," Mr. Kains-Jackson has remained more or less unimpeached; and our manufacturers, our shipping and our railways, all of which, as things stand, depend largely upon the prospects of the grain trade, are thought to have indicated some symptoms of distrust with regard to the prospect before them for the coming year.

Should such distrust exist, I hope that it may tend at least in some degree to dispel it, if I here express the strong conviction that it is entirely groundless, and that during the ensuing harvest year, as hitherto, in the past, our surplus wheat will find as ample and profitable a foreign market—aye, in England, too,—as can be reasonably desired, and that, therefore, neither our domestic industries nor carrying trade, by land or water, should suffer anything from the misrepresentations that have been made.

And now to Egypt.

History.

Of the ancient history of this most interesting country, I need only say that it began in the remotest past and ended with the Persian conquest about 500 years before our era. About 200 years later, Egypt became a Greek province, under Alexander, and about 300 years later still, or at about the commencement of our era, it fell beneath the arms of Rome. This was the period, when, with reference to its function of supplying the markets of the city of Rome with corn, it was called the granary of the world. It was estimated by Greek and Roman writers to have contained at its most flourishing period a population of 7,000,000. With alternately Pagan and Christian rulers, as one or the other Roman faction succeeded in obtaining control of its government, Egypt remained in an anarchical state until the year A. D. 616, when the Persians again took it. They held it for ten years and surrendered it to the Arabs, who held it for 900 years.

At length, in 1517, it was conquered by the Turks, who—not without having for a time lost it to the Marmelukes, who in turn lost it to the French—have retained it to the present time.

Thus, from the most ancient period, Egypt has been an enslaved country—a fact whose reflection can be seen at all times in the extreme misery and abjection of her people. For the continuance of this wretchedness, England—but for whose interference forty years ago, the Pasha would have liberated his country from the Turkish yoke—is chiefly responsible. When that yoke is cast off and the Pasha, deprived of his

present excuse for the tremendous exactions he imposes upon the people, is rendered clearly responsible for their condition and welfare, Egypt may for once in almost countless years breathe the air of freedom. But until then it is impossible.

Napoleon reminded his soldiers that forty centuries of historic time looked down upon them from the pyramids. Let us, of England and America, whose heritage for over 600 years has been the largest freedom, and whose boasted mission it has been to place this priceless boon within the reach of all the men of earth, remember that from the appealing eyes of this unhappy people forty centuries of suffering look *up* to us.

After the departure of the French from Egypt, the Turks and Marmelukes were embroiled in civil war. This ended with the accession of Mehemet Ali, as Pasha, in 1805. In 1811 this usurper treacherously slew 500 of the Marmelukes and since that time Egypt has been in peace. In 1848, at the age of 80, Mehemet Ali became imbecile, and his eldest son Ibrahim reigned in his stead. Ibrahim died in two months and was succeeded by his brother Abbas, a profligate. Mehemet Ali died in 1849 and Abbas in 1854. To these succeeded the fourth son of Mehemet Ali, Said Pasha, who reigned until his death in 1863, when his nephew Ismail, the present ruler, ascended the throne. Ismail Pasha, granted the title of Khédive by an imperial firman dated 1867, is the son of Ibrahim Pasha. He was born in 1816; educated at the Paris Polytechnic School: speaks French and a little English; owns or manages everything in Egypt, among the rest, it is said, 27 palaces for his personal use; lives precisely the same despotic and luxurious life that his predecessors, the Pharaohs, did, thousands of years ago; like them he surrounds himself with foreign adventurers; like the Pharaohs, too, he builds the most astonishing and useless works of art; and like them crushes his unhappy people—the great bulk of whom are of the once warlike and progressive, but now despised Arab race—crushes them to earth with a disdainful and merciless scorn that finds its only fit expression in the bastinado and death.

Natural Resources.

Egypt has but a single natural resource—the Nile. There is no other river in the country; nor has this one a branch or affluent between its mouth and the Nubian desert. Beside the almost shelterless date-palms, there are no trees; the few wooded parks planted by order of Mehemet Ali, the ornamental trees of the cities, of which it is said Cairo and its suburbs contain 40,000, and the mulberry trees raised for silk worms—scarcely deserving to be mentioned in this connection. There is little or no rain; the agriculture of the country depending almost entirely upon the irrigating canals connected with the Nile.

Number of rainy days at Cairo from A. D. 1798 to 1800, about 15 a year; from 1835 to 1839 about 12; in 1871, 9. Quantity of rain in 1835,

17 millimetres; 1838, 11; 1839, 3; in 1871, not recorded, but the rain fell altogether only 9 hours during the year. Same climate throughout all Lower Egypt; while in Upper Egypt it is nearly the same.

There is no wood for fuel or building purposes, neither is there any coal. In day-time it is often bleak; at night-time chilly; though, for the most time the temperature is warm and sometimes uncomfortably hot.

Moneys, Weights and Measures.

1 para	equal	to	⅛ of 1 cent U. S. gold.		
1 piastre	"	"	5 cents	" "	(a)
1 feddan	"	"	1.0323	acres.	(b)
1 ardeb, measure,	"	"	5.	bushels.	(c)
1 " weight,	"	"	270.	lbs. avoir.	
1 oke, oque, or occue	"	"	2.205	" "	(d)
1 cantar, cantaro or quintal	"	"	97.023	" "	(e)
1 kilometre carré	"	"	0.386	sq. miles.	
1 square mile	"	"	640.	acres.	

(a). The U. S. Treas. Reg. 1874, p. 486, fix the value of the Egyptian silver piece of 20 piastres at $1.0039. U. S. Consul Thayer (C. R. 1862, p. 582) says, 21½ piastres equal one dollar. The Treas. Monthly Stat. Mar. 1872, say that the Egyptian copper coinage has been recently much debased, but this does not necessarily affect the value of the silver or legal tender or "custom-house" piastre of Egypt. There was debasement of the inferior coins in 1837, also.—MacGreggor.

(b). The Alm. de Paris, 1869, says a feddan equals about 4200 mètres carrés. As a mètre carré equals 10.7064 square feet (Craig), 1 feddan equals 44,967 square feet; and as 43,560 square feet equal 1 acre, therefore 1 feddan equals 1.0323 acres. The U. S. Com. Rel. 1873, p. 1083, says a feddan is less than an acre. The M. S. 1872, say "about 1¼ acres." Buckle, Hist. Civ. (ed. Harper) v. 1, p. 61, says 1¾ acres, and Simmond's Com. Dic. says "about 1½ acres."

(c). The U. S. Com. Rel. 1859, p. 358, and 1873, p. 1083, and the general weight of authority. On the other hand, Buckle 1, 62, says it is less than 1-15th of a bushel; Kelly's Cambist says ⅛ to ⅓; Simmonds says ⅓ to 7¾ to 9¼, while the U. S. Com. Rel. 1871, p. 1107, say an ardeb is 15 bushels! The truth is it varies in all parts of Egypt. There are the Alexandria (used in the text on account of its greater universality), the Cairo, the Damietta, the Rosetta and many other ardebs. The Cairo ardeb is 1.821 hectolitres.—MacGreggor.

(d). U. S. Com. Rel. 1859, p. 358. But the C. R. of 1871, p. 1107, say 2.75 lbs., and Martin's Year Book and Kelly's Cambist say 2.832 lbs. It has not been used to obtain any of the numbers in the text.

(e). 1 cantar or cantal equals 44 okes or 100 "rottolis" or "rolls." Kelly's Cambist and the general weight of authority. But the Com. Rel. 1859, says 100 lbs.; Kelly says 95 lbs., which contradicts his previous statement, while other authorities say, variously, 97, 98¾, 112 lbs., and other equivalents.

TOTAL AREA OF EGYPT.

[Excluding the Soudan. (*f*)]

CITIES AND PROVINCES.	AREA—ACRES.	POPULATION. CENSUS MAR. 22, '71.
Cities of Alexandria, Rosetta, Damietta, Port Said and Suez, including 83,555 foreigners		654,569
Lower Egypt, including 4,483 foreigners	160,866,560	2,615,798
Middle Egypt		599,596
Upper Egypt		1,333,442
Nubia	230,440,960	3,238,595
Senaar and Meröe	130,692,480	
Massawa, Souakin and *Taka*, Provinces on the Red Sea, say	70,896,000	
Total	592,896,000	8,442,000

EGYPT PROPER.

Egypt proper consists of Lower, Middle and Upper Egypt. It contains 160,866,560 acres of area, and a population (in 1871) of 5,203,405. It is to this country only that the following statistics appertain, the outlying provinces and protectorates being omitted, as desert or savage countries.

ARABLE AREA.

The arable area of Egypt is confined substantially to the inundable portion of the valley of the Nile. As the river closely hugs the hills and palisades on its right bank, this area is nearly altogether on its left. In some places the arable lands are eleven miles wide; in others they dwindle to a mere strip of bank. For the most part, however, this area extends westward from the river about five to eight miles, where it is terminated by the Libyan hills and desert. Every year it is extended by the rise of the river upon its own bed. This rise was found to be, at the close of the last century, 4.960 inches per century. Some thirty years ago it was computed at 5.736 inches per century. From this source it is said that about 65,000 to 70,000 feddans of area are annually reclaimed from the desert (C. R. 1873, p. 1070); but, as will presently be shown, there may be as much or more lost from other causes; the area of cultivable land depending more upon social and industrial, than natural events.

(*f*). The *Soudan* Provinces include the Valley of the White Nile to the great N'Yanza Lakes and extend across the Continent of Africa westward from Nubia and south of Sahara. Their entire area is estimated at 1,600,000 square miles (about one-half the area of the United States), and it is said to contain 14 million feddans of land susceptible of cultivation (C. R. 1873, p. 1081), and a population of 60 millions, negroes. The south-eastern extremity of the Soudan was recently taken possession of by Sir Samuel Baker in the name of the Egyptian Government. It is accessible by small steamers from the lower Nile, and a railway is projected via Khartoum and Gondokoro.

In 1833, Egypt was estimated to possess 3,500,000 feddans of cultivable land, "if cultivation were pushed to its utmost extent."—MacGreggor.

The official survey of 1843 comprised 6,984,135 feddans susceptible of cultivation; but this included the superficial surface of the Nile and canals. The cultivated, and, doubtless, the cultivable, portion (at that time) consisted of 3,826,340 feddans as follows:

Provinces.	No of Feddans cultivated.	No. of Feddans uncultivated, including Surface of Nile and Canals.
Lower Egypt	2,749,106	1,551,011
Middle Egypt	750,409	843,608
Upper Egypt	826,825	763,176
Total	3,826,340	3,157,795

The report of 1843, and also a late report of the British Consul, are so worded as to convey the impression that there is almost as much cultivable land uncultivated as there is cultivated; but this is not the fact. The so-called cultivable land, not cultivated, consists, and has always consisted, for the most part either of the surfaces of the Nile and the canals, or of lands in the Delta and elsewhere, which from various causes have become barren or unavailable.

"A perpetual struggle is carried on between the desert and cultivation. In many parts of the Delta the desert has invaded and mastered the soil."—MacGreggor, 1833.

"In the Faioum, which was formerly the most richly cultivated part of Egypt, the desert has made many inroads."—*Ibid.*

"In * * * places on the western border of the Nile Valley, the shifting sands of the desert have encroached on the domain of cultivation."—Com. Rel., 1863, p. 532.

"When the land, as has happened in Lower Egypt and the Delta, from the despotic appropriation and thriftless husbandry of * * * rulers, has become what is called *aladish*, and gone to waste, light plows (such as are used here) are powerless to improve it. Villages, for example, often deprived of laborers to furnish recruits for foreign wars, were at one time depopulated by the government, and their lands exploited (used up) by a short-sighted and ruinous system of agriculture, from the effects of which the country still suffers. In order to have an uninterrupted succession of crops, the inundation (of the Nile) was excluded by dykes, irrigation being supplied from the brackish water of wells. The deposit of salt after evaporation, added to that which would be pushed to the surface by the upward filtration of the Nile, would soon convert a once fruitful tract into a desert, where nothing would grow but a rank crop of 'halfa,' a deep-rooted, tough grass, which, with the ordinary farming implements of Egypt, it is almost impossible to extirpate. It has thus

been considered an unprofitable undertaking to attempt to improve these barren lands, raised, as they frequently are, by the deposits left by former growths of this pestilent grass above the level of inundation, and from this cause *one-half of the Delta is said to be uncultivated.*"—*Ibid.*

This alone would dispose of some two millions of acres.

"Part of the (barren) territory (now being reclaimed by the Suez Canal Company) was known in ancient times as the fruitful land of Goshen."—*Ibid.*

"A large part of the land formerly cultivated in Egypt is to-day sterile."—*Ibid.*

"In the present cotton region the land has become so poor that now only two cantars a feddan are produced where five used to be gathered. * * * There is plenty of land; it only wants moisture to make it fertile; and we would like to see a number of irrigating canals," etc.—C. R., 1866, p. 435.

The accounts are the same to the present day.

The following table shows the cultivated area at several dates, from 1812 to 1874 inclusive:

COMPARATIVE STATISTICS OF CULTIVATED AREA IN EGYPT.

YEAR.	FEDDANS.	ACRES.
1812	3,218,736	3,322,701
1833	1,856,000	1,915,950
1835	2,000,000	2,064,600
1843	3,826,340	3,949,931
1868	4,296,736	4,435,521
1873	4,624,221	4,773,583
1874	4,625,000	4,774,388

This table shows, that from the time of the accession of Mehemet Ali, to the close of the war in Syria, the cultivated area in Egypt rapidly declined. It then suddenly increased until, in 1843, it attained its former extent again. From that time to this it has slowly increased. The causes of this extraorinary movement will appear when the progress of the population has been examined.

POPULATION OF ALL EGYPT.

(Excluding the Soudan.)

YEAR.	ESTIMATED POPULATION.	AUTHORITY.
1862	7,465,000	Dr. Schnepp.
1871	8,442,000	Dr. Wagner.

The Almanac de Gotha for 1873 gives the population, at a recent date, at 8,000,000, and appears to quote Mr. E. de Regny, the official statistician of Egypt, for authority.

Population of Egypt Proper.

YEAR.	POPULATION.	AUTHORITY.
1812	3,000,000	Estimate.
1820	2,500,000	Morse's Gazetteer.
1833	2,000,000	MacGreggor.
1844	3,350,000	Alm. de Gotha.
1847	4,542,620	Census.
1859	5,125,000	Census.
1863	4,709,116	Com. Rel., 1873.
1866	4,848,528	Br. Con. Ret., 6–1867.
1867	4,888,925	Com. Rel., 1873.
1872	5,203,405	" " "
1873	5,250,000	" " "

This table exhibits a decrease of population from the time of Mehemet Ali's accession, to the close of the Syrian war, similar to that shown with regard to acres of cultivated area. It likewise shows the same sudden growth immediately afterward, and even a slower growth since. These coincidences are undoubtedly due to the same causes—the wars of Mehemet Ali, particularly those in Syria; the abandonment of the country for the desert, in preference to participation in those wars; and the subsequent return of the people from the battle-fields and the wilderness. Says MacGreggor, "Almost without exception the laborers mutilated themselves by cutting off the first finger of the right hand, destroying the right eye, or pulling out the front teeth, in order to avoid the conscription," p. 231.

Comparison of Population and Cultivated Area.

If the large estates worked by the Khédive and his relatives, or the nobles of his court, be deducted, there will not remain in Egypt over one-half an acre of arable land to each person; and even if the land cultivated at present were divided equally among all, there would still be not over nine-tenths of an acre per capita. To show how comparatively small an area this is, I give the statistics on this point relative to the countries with which we are most familiar.

RELATION OF CULTIVATED LANDS TO POPULATION IN FOUR DIFFERENT COUNTRIES.

Country.	Year.	Cultivated Lands. Acres per Capita.		Cultivated Lands, including pasture and forest lands in use. Acres per capita.	
United States (g).....	1850	4.9	Average, 3.3	12.7	Average, 6.5
	1860	5.2		13 0	
	1870 (h)	4.9 (h)		10.6 (h)	
United Kingdom.....	1873	1.4		1.5	
France.....	1872	2.2		3.1	
Egypt.....	1873	0.9		0.9	

The United States is an agricultural country, which furnishes other countries with breadstuffs out of its own surplus. The United Kingdom is a manufacturing country, which has abandoned the policy of attempting to raise its own breadstuffs, and relies largely upon foreign supplies. The quantities of the latter—that is to say, all breadstuffs (not wheat alone)—usually exported by the United States, do not materially exceed those usually imported by the United Kingdom; hence an average of the amount of cultivated land per capita in the two countries shows very correctly the true amount needed to support each head of population. According to the table above, this average is over 6½ acres. In France, which imports breadstuffs as often as it exports them, and whose population and means of subsistence are running a close race, the average number of acres to each head of population is over three. Imagine how small, then, must be the portion of an Egyptian laborer, who, if even he had a fair share of all the cultivated land in his country, which is far from being the fact—who, if that land were as productively tilled as are the lands of the other countries named, which, as will be presently shown, is not the case, and who, if all the food-products of that land were kept at home instead of being shipped abroad, as a large portion of them are, would still possess but one-seventh the heritage of an American or Englishman, and but one-fourth that of a Frenchman.

RURAL AND CIVIC POPULATION.

There are few towns in Egypt beside those already specified. Among them is Syout, with a population estimated in 1874 at 25,000 (Contemp. Rev., Feb. 1874.) The total civic population of Egypt is estimated at

(g) The lands classified in the United States census as "improved farm lands," are treated above as "cultivated lands," and the "unimproved farm lands" as "pasture and forest lands in use," as adjuncts to agriculture. "No farm of less than three acres, not unless $500 worth of produce has been sold off it during the year," is included in the United States census returns—a very absurd and misleading exception.

(h) The United States census of 1870 was the worst ever taken, and is palpably deficient in almost every respect. The census of 1860 is much more complete and reliable.

700,000, or 13 per cent. of the whole, leaving the rural population to consist of 4,503,405, or 87 per cent. of the whole.

Occupations.

There are no manufactures in Egypt except those owned and managed by "the government," or, in other words, Ismail, son of Ibrahim. The principal ones are the two cotton cloth factories which supply the coarse white cotton clothing used by the soldiers, and the blue stuff of cotton and wool worn by the peasant women. One of these is at Boulac, the other at Choubra, near Cairo. Together they employ 1,438 workmen, and produce annually $122,970 worth of cloth and $13,740 worth of linen —an average of $95 per workman. There is a manufactory of tarbooches (these are the national cap) and carpets at Fueh; a printing establishment at Boulac for Turkish and Arabian works, which employs about 150 workmen; a paper-mill at Boulac, which employs 50 workmen, and produces annually 350 cantars of wrapping, and 66,500 reams of printing, writing and colored papers; two gunpowder-mills worked by mule-power, near Cairo; several large bakeries at Cairo, which together consume about 800,000 barrels of flour per annum; and some other small works.

These, with the salt-works monopoly, which turns out some 360,000 bushels of salt per annum; the fisheries, which employ 3,760 persons on salt, and about 6,000 on fresh, water; seventeen short railways and branches; the telegraphs, the Nile steamboats, and a few navigable canals, are all the industrial works in Egypt, unless the manufacture of native sugar and ginning of native cotton are included in the same category. They are all owned and managed by the Khédive, who, by thus engrossing all the branches of trade, effectually crushes native, and shuts out foreign, capital and enterprise. Mehemet Ali made strenuous efforts to become a cotton manufacturer, and at one time had 44 factories and 20,000 operatives, consuming annually 30,000 cantars of cotton, at work; but the enterprise was abandoned.

A considerable portion of the persons employed in the present industrial works in Egypt are foreigners; even the fisheries, employing many Maltese, Greeks and Italians. The number of those employed in agriculture, including their families, is estimated at 4,400,000, or about 85 per cent. of the whole population—a number and proportion nearly identical with those of the entire rural population.

Size of Farms.

The Viceroy, or Khédive, and his family cultivate one-fourth of all the arable land. A farm of the late El Hami Pasha consisted of 39,368 acres, of which 13,344 were let. There are other large estates. The holdings among the fellahdeen, or peasantry, range from one-eighth of an acre to one acre in size.

Land Tenures.

Theoretically, all lands were held of God by the Sultan of Turkey. In Egypt the Viceroy stood in place of the Sultan, and had power to grant

tenancies in fee, estates for life or a term of years, metayerships and other tenures, except to the mosques, which held directly from the Sultan.

But Mehemet Ali simplified all this by seizing the lands of the mosques, confiscating all the private titles, and appropriating the entire land and its people to his own use. Certain nobles and foreign adventurers have since been allowed to obtain doubtful tenures of the land, the basis of which is, however, in all cases, the Khédive's will. The portions not managed directly by the latter and his beneficiaries are cultivated by the wretched fellahdeen, and held, properly speaking, by no tenure except that which naturally attaches itself to compulsory service.

The Turkish laws of succession, designed by Mahmoud II. and Abd-el-Mejeed to put an end to the great feudatories which existed in their days, imperatively command equal subdivision of land among the heirs of the first degree in descending or ascending line, male and female alike; failing these, in collateral line, etc. Entails were abolished; transfers of real estate were to be made by entry at a public registry, and the transaction heavily taxed; private deeds between the parties were not to be recognized. How far these regulations have been applied in Egypt it would be difficult to say.

System of Culture.

The system of culture hardly deserves the name, and simply consists of waiting upon the annual overflow of the Nile to fill the irrigating canals, and when the river has subsided, of maintaining the level of the canals and reservoirs by pumping, baling and ladling. This last-named work and "the digging of fresh canals engross the labor of the people for months," writes the British consul, Mr. Stanley, in 1873. Without this incessant struggle with nature, the lands would become uncultivable, and even with it the result is doubtful; for if the next overflow of the river exceeds thirty feet in height, everything on the land is demolished and swept away; while if it falls short of eighteen feet, the harvests fail and famine ensues. Of the 66 inundations between 1735 and 1801, 11, or 17 per cent., were high and devastating; 16, or 24 per cent., were feeble; 9, or 14 per cent., were insufficient; and only 30, or 45 per cent., were good. The chances, then, appear to be about even, as to whether, after all his labor, the Egyptian gets a harvest or not. Such a system does not admit of fallows, rotation or manuring. The irrigating canals or reservoirs of the large estates are supplied with water from the river by steam power, the coal being imported from England; but for the most part this work, and the digging and dredging of the canals, ditches and reservoirs, are done by hand, and with the rudest implements.

Sometimes two, three and even four *shadoufs* or baling machines are placed close to each other and employed to raise the water by the pitcherful at a time, to as many reservoirs at different elevations, until it reaches the highest. Each *shadouf* requires two men to work it. "During many months of the year the whole Arab population appears to be engaged in bringing water from the Nile to the adjacent fields."—MacGreggor.

The total number and kinds of machines now in use for the purpose of irrigation will be shown further on.

The Nile usually rises late in May. In August it reaches such a height that the canals are opened, the entire valley is soaked and the reservoirs are filled with water. It continues to rise until October, and then falls so rapidly that, in some parts, pumping and baling commence in November or December; though, in others, not until February, when they continue until May or June.

Fertilizers.

As a general thing no fertilizers are employed; the deposits of mud left by the river during its overflow being the main dependence of the husbandman in this respect. An analysis of this mud gives the following results: silica 53.04; sesquioxide of iron 18.43; sesquioxide of alumina 8.76; carbonate of lime 4.19; sulphate of lime 0.75; lime 2.25; magnesia 0.66; potassa 0.69; soda 2.16; chloride of sodium 0.04; organic matter 9.03; total 100 per cent. Owing to the extreme scarcity of trees and entire absence of coal, fuel, for all purposes, is exceedingly dear. For this reason animal manure, and during the cotton excitement 1862–1867, even cotton-seed, the price of which had at former periods exceeded that of wheat, were used for fuel; and the former continues to be thus employed yet. Cotton-seed, however, degenerates so rapidly in Egypt that, except for this purpose, or the superior ones of extracting oil from it or using it for cattle fodder, it possesses little value there, unless it is freshly imported from other countries. The Khédive has promised a large pecuniary reward and the title of Bey to whomsoever shall discover paying deposits of *coal* in Egypt.

On the sugar estates the culture exhausts the earth so rapidly that pigeon-guano is largely used to enrich it; about half a ton being employed to the acre of land. In order to obtain this fertilizer the keeping of a flock of pigeons is part of the fellah's duties to the state. The birds are simply provided with the shelter of a mud-cote and left at liberty to provide their own sustenance. This, of course, is derived, one way or another, from the fellah's corn-field, and in this way the birds constitute an additional agency of taxation upon the wretched peasant. About 267,000 tons of this guano are now annually produced in Egypt.

In justice to the Egyptian system of agriculture, it should be stated that there *is* a certain rotation of crops observed, but unlike any other system known, except that of the despotic President Lopez, who runs a government in South America which is somewhat ironically styled the "republic" of Paraguay, the order of that rotation is governed altogether by the will or caprice of the Khédive. Rice and maize used to be largely cultivated in Egypt; but the government ordered wheat to be planted in their stead and the latter became the principal exporting crop. It was grown one year after another, until nature gave out and the grain grew so poor that it could scarcely find a market. That exported to England

was used only in the distilleries. The American war occurring at this juncture, the government prohibited the cultivation of wheat and nominated cotton in its place. The culture of this staple was pursued until the fall of prices occurred after the war, when it was superseded in turn by sugar, which is the present favorite. The exports from Alexandria, the shipping port of the country, which will be given further on, will furnish a close guide to the fluctuations in the product of these articles, occasioned by this capricious, ruinous, and sometimes mortal policy.

Seeding.

The seed is thrown broadcast, the use of the drill being wholly unknown. About 3½ bushels of wheat are sown to the acre, the produce being 11¼ bushels, or scarcely more than 3 for 1. Even ploughing was formerly dispensed with in many parts, the seed being thrown upon the mud left by the receding river, and domestic animals turned loose to trample in the grain. This and other wretched features of Egyptian agriculture are giving way before better methods. The cotton and sugar-cane which now constitute the chief products of the country, are cultivated mainly by the large proprietors and sown, or planted, as in the United States.

Domestic Animals.

Previous to the cattle disease in 1863 and 1864 which destroyed in a single year 800,000 head of horned cattle, and, in Lower Egypt, nearly every other animal also, and which, together with the cotton mania of that period, contributed to occasion the famine of 1865, the number of domestic animals must have exceeded one million. At the present time it barely amounts to two-thirds of that number, as follows:

Horned cattle (including buffaloes, the main dependence of the peasant for the work of the farm)	292,100
Horses	18,203
Mules	2,105
Asses	94,641
Camels	35,578
Sheep	172,657
Goats	23,907
Total	639,191

These numbers do not include the animals in Alexandria and Cairo. During the year 1872 there were imported at Alexandria 14,185 head of cattle and 200,087 sheep, chiefly for slaughter.

In 1871 the average prices of 71,400 animals sold at the fairs of Tantah in the Delta, were reported by the American consul as follows: Cattle $200 each; buffaloes $175; camels $200; horses $100; asses $25; and sheep $6.25. (Doubtful.)

Wages.

In common with many European and all Oriental countries, women in Egypt are employed in field labor. The following were the prices of labor current at four different epochs. Men's wages per diem are always meant unless otherwise specified.

Year 1837.

Field laborers	Lower Egypt	$0.02½ @ .05
	Upper "	.02½ @ .02¾
Boys and girls, sugar plantation		.01¼ @ .03

Year 1841.

Laborers, at Cairo, average	.05
Keepers, or gang-leaders	.10

Year 1863.

Night operative in cotton-gin at Mansurah	.24½
Day operative, same work, boy or girl	.12
Laborer on Suez Canal	.20

This was the period of the cotton mania. The American consul, writing at the time, said, "within a year wages have been doubled."

In 1865 the American consul reported that there had been an important rise in wages in late years, mainly due to the redundance of specie caused by the high prices at which cotton sold.

In 1867 the British consul reported that "wages and land had quadrupled."

Between this period and 1873 there seems to have been a fall in wages.

Year 1873.

Field laborers	Lower Egypt,	.15
	Middle "	.10
	Upper "	.07
Unskilled operatives in factories and at salt works, according to age and ability, 15c. @ 40c. per diem, average		22½
Mechanics, such as masons, carpenters, blacksmiths, etc., without board or ration		.60 @ 1.00

The American consul reported in 1873 that wages appear to have declined since the cotton mania, but that they are said to be now rising again.

Efficiency of Labor.

An Egyptian laborer is considered to have done a good day's work when he picks 15 to 18 pounds of cotton. The American negro slaves usually picked 50 pounds in the same time. An Egyptian with the aid of a *shadouf* (pole and jar, or bucket) can raise for irrigating purposes an average of about seven gallons of water per minute; an American with an improved hand pump can raise 100 gallons per minute, or 14 times as much. The constant use of the stick and bastinado is necessary to keep at work the fellahdeen on the Khédive's estates (C. R. 1871). This fact

may, however, be due to other reasons than mere physical infirmity. The immediate labor of about 15 persons out of every 100 in the United States produces more than enough food for all; whereas in Egypt the same result calls for the immediate labor of at least three times as many persons; while the result itself is greatly inferior in quantity, quality and variety.

That this great comparative inefficiency of Egyptian labor is due less to natural inaptitude than to poor food, rude implements and other circumstances over which he has no control, is manifest from the recorded observations of very intelligent persons.

Says MacGreggor, writing of Egypt, "The Arabs, if brought young to the cotton factories are of quick intellect and easily learn any branch of the trade." * * * "They show considerable dexterity."

Says Dr. Rüppel: "The young Egyptians show great skill and often surpass their masters in cleverness."

Taxation.

The tax system of Egypt is contrived to keep its unhappy people precisely at the point where it is a matter of the utmost unconcern to them whether they live or die. It is impossible to ascertain what this burden amounts to in money, but substantially, it deprives the population of all the fruits of their industry, leaving them but a bare and most wretched subsistence, without lands, homes, clothing, security, justice, or education —and, but for dates and dourra, even without food. The peasant's home is far less comfortable than that of some wild animals—for instance, the beaver. It is of the same character as the latter—a mud hut—and teems with vermin. Great numbers of the people live in the ancient tombs, with darkness and the bats.—Stephens' Travels 1837. The dress of the people hereabouts (at the First Cataract, the confines of Egypt proper and Nubia) consists of a piece of leather about six inches wide, cut in strings and tied about their loins. I bought one from a young girl of 16, whose sweet mild face and exquisitely charming figure the finest lady might have envied.—*Ibid.*

Men are seized in the streets, the bazaars, anywhere, "the iron bands put around their wrists, the iron collars around their necks," and forced to work for the Pasha.—*Ibid.*

"People are taken away in gangs from their own ground to do work for powerful land-owners, which in no wise benefits their districts." —British Consul Stanley, 1873. "A man was convicted of stealing an amber mouth-piece from Abbas Agga. His punishment was to be bound to a cannon and blown to atoms. The same official pressed 600 fellahs into his service to dig him a canal; made them work 12 hours a day; lashed them unmercifully, and did not pay them a single para."—Dr. Holroyd's Travels, 1837. The Koran is the only book in the land and that it is considered sacrilegious to print. Those few who can read and write are called fickees or saints.—*Ibid.* The people are strictly temperate, exceedingly docile and naturally intelligent.

In 1837 the *miri* or land tax was from $1.75 per feddan per annum on ordinary lands, to $5 on sugar lands. It is at present, 1874, about $5 per feddan on all lands. Beside this, there is a poll tax; a tax on date trees, which, as elsewhere explained, is equivalent to an additional poll tax; octroi taxes on the principal articles of consumption; tolls to support the irrigation canals; taxes on the fisheries (one-third); on salt; on the consumption of wheat ($1) and barley, beans, Indian corn, and pulse (75 cents per bushel in 1837); import and export duties; monopolization of all the branches of industry by the government; forced service; debasement of the copper coinage and every other device of a vicious and merciless finance. Beside these, there are dues to the mosques and various local exactions.

The total revenues of the Viceroyalty in 1821 were about $6,000,000; in 1833 about $12,500,000; in 1850 about $20,000,000; in 1872 about $36,500,000. This last sum is equivalent to 10 cents per day for every family in the country, or the whole value of the labor of every father, or head of family. The same rate of taxation—that is, the whole value of one man's labor exacted from each family in the land—were it possible in the United States, would amount to 8,000 million dollars per annum, or four times the whole sum of the national debt. But thank God, it *isn't* possible.

The taxes are raised in Egypt through a *Sheik-el-belled* or head of village commune, chosen by the people and against his will, for although armed with arbitrary power, should he fail to collect the heavy tribute, his life is generally forfeited. The government sends him in chains to the Southern frontier and he is seldom heard of again.

Interest.

The Mahometan law, like the canon law of Christianity and the ancient Jewish law, forbids the taking of interest; but like those laws, it has fallen into disuse in this respect. In 1837 the Viceroy allowed 6 per cent. for advances to him from European houses.—MacGreggor. At the same time the market rate for money among mercantile houses in Egypt was 10 to 18 per cent. per annum. At the present time the rate of interest ranges between 10 per cent. on the most desirable class of government securities, to 60 and even 100 per cent. per annum on fair commercial risks. These excessive rates appear to result less from high profits than great insecurity and the lack of a basis of individual right for an administration of justice. The prevailing insecurity is susceptible of being illustrated by four striking examples. 1st. The tenure of lands is merely the will of the Viceroy. 2d. In 1866 the Viceroy informed the European resident creditors of the rural population that, in future, it would be useless for them to claim against the natives.—Br. Cons. Rep. 6–1867, p. 296. 3d. In 1864, though gold was at that time pouring into the country to pay for cotton, so overwhelming was the general instinct to hoard and bury money, that little or none of it remained in circulation. "On one

occasion, when the French packet from Marseilles arrived in the afternoon with seven millions of francs in specie, I was informed by the agent of the company, the same evening, that he had reason to believe that not a single coin of the whole amount had remained in Alexandria. It had been taken to the villages where it is generally buried in the earth."—Com. Rel. 1865, p. 484. 4th. The monopolies. In 1864, during the high price of cotton, the Viceroy refused permission for the cotton of other cultivators to be brought to market until his own was first shipped.—*Ibid.* In 1865 and 1866, though there was a famine in Egypt, corn fetched a higher price at Jidda, in the Hedjaz, a province of Arabia on the Eastern coast of the Red Sea. The merchants, who hastened to ship corn to Jidda, were stopped by the Viceroy; who, disregarding the famished condition of his own people, hastened to sell his corn to the Arabians and obtain the higher prices which necessity compelled them to offer.—Br. C. R. 6-1867, p. 134.

The following quotations exhibit the rates of interest current in Egypt of late years.

1863. Three to five, and even seven, per cent. a month was paid by fellahs to the Levantine traders who lent them money wherewith to pay their taxes. Same year, five to ten per cent. a month was paid on good security.—C. R., 1863.

1864. "Minimum rate, ten per cent. per annum. Two and three per cent. a month often paid by parties of the first position for temporary loans."—C. R., 1864 and 1865.

1872. Seven to ten per cent. per annum on government securities.—M. S., 1872.

Agricultural Implements.

On the estates of the Khédive and other large planters, modern implements are in use; but the natives appear to be so ill-fed as to lack the physical strength and skill to wield them. Hence their reluctance to work on these estates, and the cruel practice of forcing them by blows; for, as things go, the Khédive pays them well. (C. R., 1871.) In 1862-3 the Khédive employed steam irrigating machinery in Upper Egypt. At the same time there were in operation eighty steam cotton-gins; steam pumps were used by other large proprietors, and steam plows were tried on the barren "halfa" lands of the Delta. (C. R., 1863.) Since that time, other improved implements have come into use on the same class of estates; but the peasants continue to employ the antique and inefficient implements common to the Orient from the most ancient times, the causes for this preference being poverty, physical infirmity and, above all, political insecurity. These implements consist of the plow, which is merely a crooked stick, sometimes barbed with iron; the mattock, the hoe, the spade, the *dulab* or hand-gin for cotton, and the *sakye* or *sakia*, the *chadouf* or *shadouf*, and the *tabout*, for irrigating purposes. The *sakye* is a horizontal wooden cog-wheel, turned by oxen and working into the perimeter of a vertical wooden cog-wheel, which, in revolving, elevates

an endless rope chain, to which are attached earthen jars. Filling with water at the bottom of the well or shaft, these jars empty themselves at the top as they begin to descend.

The *shadouf* is an upright forked pole in which turns a beam with a bucket or jar at one end and a lump of mud to balance it at the other.

The *tabout* is a basket, to be handled by two men, and only used when the water is to be raised but a few feet. The number of the various implements used for irrigating purposes in 1873 was as follows:

Steam-pumps	476
Sakyes (*i*)	30,084
Shadoufs	70,508
Tabouts	6,926
	107,994

Chief Articles of National Diet.

Dates and dourra constitute the chief dietary of Egypt. It is a remarkable fact that the number of date-trees under cultivation has generally coincided with the number of inhabitants and the number of acres of cultivated lands. The causes of this correspondence with reference to the number of date-trees are doubtless the coincidence of their period of bearing with the ordinary duration of a man's life, and their yield of fruit with the capacity of man to consume it, which for each tree and each man is alike one pound a day. These circumstances combine to render the tax, (now yielding about $700,000 per annum) which is placed upon date-trees, really a tax on polls, of both sexes and all ages, amounting to about 14 cents per capita.

There are now about 5 million date-palm trees in Egypt. The trees are raised by shoots, arrive at their vigor in about 30 years, and continue so for seventy years afterward, bearing yearly fifteen or twenty clusters of dates, each of them weighing fifteen or twenty pounds. After this period they begin to decline. Upwards of 200 trees are sometimes planted on a single acre (Buckle, 1, 61). Wilkinson, from whom Buckle quoted, said 400 to a feddan. Accepting the lower number as nearer the truth, it would follow that 25,000 acres of land are devoted to the growth of date-palms in Egypt. The average annual yield in 1873 was four cantars of dates to each tree (C. R., 1873, p. 1086). This would make the aggregate yield about 20 million cantars. All but 30 thousand cantars, or one-sixth of one per cent., which is the amount annually exported, are consumed in the country. Dates are not used for human food alone, but

(*i*) The number of *sakyes* in use in 1838 was estimated at 50,000, costing 3¾ million dollars a year to work them, the power employed on each machine being that of two cattle and one man (C. R., 1838, p. 533). In 1837, for want of pruning-hooks or knives, the fellahdeen engaged in cultivating cotton in Upper Egypt, broke off the branches instead of cutting them; while for want of a press, the bale of cotton was packed with the foot (MacGreggor). The absence of so common an instrument as a knife is due to the fact that the government prohibits the bearing of arms by the populace. The prudence of this precaution is evidenced by the following extract from Stephens: "Speaking of the general poverty of the Arabs, the Sheik said that if one-fourth of them owned a musket, one charge of powder and one ball, before morning there would not be a Turk in Egypt."

are also fed to horses, asses, camels, sheep, fowls and dogs, the animals consuming all the abortive fruit, and even the date-stones, when softened in water and ground up, the latter being often collected for the purpose by indigent persons. The young shoots of the date-palms are used as a delicate vegetable, resembling asparagus; the leaves afford couches, baskets, bags, mats, brushes, etc.; the trunk affords wood for fences, fuel, etc.; the fibrous part, cordage and thread; the pith, starch; and the sap, a fermented liquor.

Dourra (*j*), indian-corn, blé turc, millet, sorghum (*S. vulgare*), or Guinea corn—for it is known by all these names—is a species of *holcus* (allied to broom-corn, etc.), and the principal grain of Egypt next after wheat. Varieties of this grain are grown in Africa and Asia, and it has been tried in Pennsylvania, Massachusetts, California and elsewhere in the United States, for use as cattle-fodder, but abandoned (except in California, where its cultivation was only begun a few years ago) in favor of oats or barley. Next to dates, it forms the staple food of the Egyptian peasant, and in Upper Egypt and Nubia particularly. Indeed, in Nubia it is used for the purposes of currency. Wishing to prove the prolificacy of dourra, and quoting Hamilton's *Egyptiacæ*, Buckle says (vol. 1, p. 62) that "it yields to the laborer a return of 240 for 1." It is possible that a single grain will yield a plant bearing 240 grains; but this degree of prolificacy is exceeded by maize and many other cereals. Therefore, taken by itself, this fact means nothing. But if Hamilton meant that the average yield of large areas sown in dourra is 240 for 1, which is what Buckle took it to mean, this statement is as wild as his other, that an ardeb is 16 bushels. Nor does it signify, in this connection, that, to quote another author (Appleton's Encyc. Art. *Millet*) a bushel of millet has been grown on six square rods of land, which is equal to 26⅔ bushels to the acre. The practical fact is, that in Egypt, at the present time, dourra yields on the average about 12 bushels to the acre (the C. R., 1873, p. 1085, say 2¼ ardebs per feddan), or somewhat more than wheat in the same country. Its preference to the latter is doubtless due either to the lesser amount of seed and care required in its cultivation, or to the lesser trouble required in its preparation for use. It is ground between two stones and made into a brown bread, said by an enthusiastic traveler to be of "admirable quality" (Contemp. Rev., Feb. 1874), but is greatly deficient in flesh-forming materials. Hamilton says, that "in Upper Egypt the dourra constitutes almost the whole subsistence of the peasantry;" but this is so far from being correct, that they eat several pounds of dates to one of dourra. Although its use in Egypt is less common as one proceeds from Nubia to the Delta, it is nevertheless still largely consumed in Middle Egypt. The lotus, which was used for food in the time of Herodotus, is now almost a rare plant.

Beside dates and dourra-bread, the food of the Egyptian peasants consists largely of beans and lentils, which are made into soups and other

(*j*) Spelled variously, as dourra, dourrah, dhourra, dhurra, dourah, dowrah and durr

dishes. A very little fish is obtained, but no meat, except on rare occasions, when a sheep is slaughtered and consumed, even to the entrails. The total cost of an adult peasant's subsistence in 1837 ranged from 1 to 2½ cents per day. It is now, 1874, 3½ to 7½ cents. So effectually does the government deprive the people of the means of subsistence, that says MacGreggor: "If the poor fellah does not secrete some of his produce, it sometimes happens that *nothing* is left him at the conclusion of autumn to maintain himself and family through the winter."

Navigable Rivers.

The Nile is navigable by light draught boats from its mouths to the rapids or cataracts, about 600 miles above. The draught of water in the Rosetta mouth is five feet, and in the Damietta, eight feet, at low tide. During the inundation, the draught is often forty feet, and large vessels can ascend to Cairo.

Navigable Canals.	Miles long.
Mahmoudy, Lower Egypt	50
Ismaïlia, " "	61
Beherah, " "	30
Ibrahimieh, Upper "	93

Beside these, there is the Suez International Ship Canal, 69 miles long; the Bahr Yusuf, or ancient irrigating river of Joseph, some 300 miles long; and hundreds of irrigating canals, many of them of great size, not to count innumerable runnels and ditches, for the purposes of irrigation.

Railways.

The following table shows the progress that has been made in railways in Egypt:

Year.	Miles.
1863	245
1871	654
1873	736½

In 1873 there were completed twenty-one railways, aggregating 736½ miles, of which about 200 miles were double track; also, in progress, 208 miles and a single railway of 600 miles to the Soudan.

But with all this progress, says British Consul West, in 1867, "the trade of Suez is on a most limited scale, and is almost exclusively confined to the supply of the daily wants of its few inhabitants. The imports from the Red sea or from India are all on account of the Cairo merchants, and the goods are received here by native wakeels, or agents, simply as forwarding agents. The duty is paid on them, and notwithstanding the line of railway between Cairo and Suez, they are transmitted not unfrequently on camels!"

The Consul explains that there are several reasons for this singular preference, neither one of which is creditable to the existing government, which not only lords itself despotically over the people, but owns, monopolizes and administers the railways.

First. "The natives avoid coming into contact with the government officials," who manage the railways.

Secondly. "Time is of but little object, and the saving of it, *if any, by rail,* is questionable, owing to the delays in forwarding and obtaining delivery of the goods."

Thirdly. "The rates of railway freights are so high as to make but little, if any, difference in the cost."

Though it should be remembered, in mitigation of this charge, that all of the materials, some of the *personnel,* and, most important, all of the coal for the railway service has to be imported from Europe; yet the Consul's reasons for the avoidance of the railways involve reproaches to the Khédive's system of rule, which appear to show that even with cheap fuel, railways and despotism will not work well together.

The converse of this induction, that railways need a free government for their development, is strikingly shown in the great progress which the former have made in this country, and the relative progress they have made in all countries.

When it is remembered that thousands of years ago Egypt possessed stone railways, and perhaps also wooden ones, it is rather a dark stigma on the Khédive's rule that, with all his efforts to imitate European progress, the government he has established is so distasteful to his people, that rather than employ his boasted engines of progress, they find it preferable to return to the camels and the old paces and slow ways of their forefathers.

Of telegraphs there were in 1863 about 360 miles, and in 1873 about 3,460 miles. These works all belong to the government.

Rates of Freight.

In 1863 the freight on baled cotton by railway from Mansurah to Alexandria, a distance of about 100 miles, was 48 cents per cantar, or, say, 55 cents per cwt. Rates of freight from Alexandria to Liverpool in 1873, for wheat and beans 61 cents @ $1.34 per quarter of 8 bushels; to Marseilles, 60 cents per 100 kilos., or, say, 17 cents per bushel.

Having now very fully examined Egypt's resources, natural, artificial and human, we turn to the practical results of these means and forces, which are summed up in her

Agricultural Products.

In 1834 the produce of Egypt was stated to Dr. Bowring as follows:

Wheat, bushels	3,144,500	Sugar, cwts	32,000
Beans, "	2,648,000	Cotton, "	206,000
Lentils, "	231,700	Flax, "	55,000
Barley, "	1,853,600	Saffron, "	3,500
Maize, "	529,600	Tobacco, "	100,000
Dourra, "	2,813,500	Hennah, "	30,000
Chick peas, "	165,500	Indigo, lbs	212,575
Lupins "	115,850	Silk, "	178,750
Helbeh (*k*) "	364,100	Opium, "	41,250
Rice "	450,160	Linseed, bushels	198,600

(*k*) A seed with a somewhat bitter taste, whose flour is mixed with dourra.

The quantities in the above table are obtained by reckoning 3.31 Cairo ardebs to the bushel and $2\frac{3}{4}$ pounds to the oke. The cwts. are as stated in the original.

In 1873 the products, feddans cultivated, average yield per feddan and total yield were as follows:

Products.	No. of Feddans Cultivated.	Av. yield per Feddan.	Aggregate yield.
Cotton, cantars (1871)	718,997	$2\frac{3}{4}$	1,977,242
Sugar (*l*) "	200,000	(*l*) 30	6,000,000
Wheat, bushels	711,000	$11\frac{1}{4}$	7,998,750
Dourra, "	400,000	$11\frac{1}{4}$	4,500,000
Barley, Rice, (*m*) Maize and other grains, bushels	89,000	$11\frac{1}{4}$	1,001,250
Oats, bushels	1,200,000	$12\frac{1}{2}$	1,500,000
Beans and lentils, bushels	1,070,000	2	2,140,000
Dates, cantars	25,000	800	20,000,000
All other, including Mulberry trees, (*n*) Rose-trees, (*o*) poppies, etc.	210,224		
Total	4,624,221		

From the above table and the comparative statistics of the exports of cotton and sugar from Egypt, it appears that at the present time the government is encouraging the production of these articles in the place of wheat, and since the area of cultivation is limited, it follows that the product of the latter will be less and less every year. But taking the wheat product at its utmost, what does it amount to? A product of 8,000,000 bushels a year, (*p*) of which 5,000,000 bushels are exported, chiefly to England. In point of fact, however, there have been but six years during the past twenty, when the exports have amounted to as much as 5,000,000 bushels per annum, and there will probably never be another—at least in our days. These years were 1854, 1855, 1856, 1858, 1862 and 1868. In 1864, 1865, 1866 and 1870, there were no exports, on account of famine. In fact, Egypt imported wheat in those years. Last year, 1873, the exports were only $2\frac{1}{2}$ million bushels.

(*l*). This statement of the yield of sugar must be accepted with caution. It is given on the authority of the American consul, but the same authority says that the total product of 1872 was but 1,500,000 cantars. The production of this article is being pushed by the Khédive and more land devoted to it each succeeding year. There are 17 factories in Upper Egypt, capable of turning out 2,350,000 cantars of sugar per annum, and 5 others were building in 1873, with an aggregate capacity of 900,000 cantars.

(*m*). Rice was formerly the principal grain exported from Egypt, but its cultivation began to decline some 50 years ago.

(*n*). There were 10,000 feddans in Mulberry trees in 1837, with 300 trees to the feddan.

(*o*). Mainly in the Faioum.

(*p*). It was about 7,500,000 bushels some ten or fifteen years previously.—Appleton's Encyc.

Conclusion.

When it is remembered that the wheat trade between the United States and Great Britain is an export of 42 million bushels a year from the former, to help supply a demand of 95 million bushels a year on the part of the latter, the utter insignificance of Egypt in this respect and her inability to supply such a material portion of this trade as is likely to have the slightest appreciable effect upon its course or prices, is believed to be evident without any further argument.

Appending, first, the commercial movement of wheat, I will close with a few words relative to the government and the future material welfare of Egypt.

Commercial Movement.

Year.	Exports of Wheat from Alexandria. Bu. (5 to 1 ardeb.)	Received in the United Kingdom Bushels of 56 lbs.	Exports to France. Bushels. (5 to 1 ardeb.)
1833 (*q*)	300,000		
1841 (*r*)	2,493,985	116,430	93,225
1853	4,828,965	3,101,850	
1854	5,078,430	2,625,176	
1855 (*s*)	8,374,260	3,789,422	652,205
1856	7,807,240	4,633,226	
1857	3,762,865	1,770,046	
1858	5,852,240	4,026,982	
1859	2,636,975	3,269,072	
1860	2,823,590	1,717,150	
1861	4,526,200	2,948,960	
1862	6,644,255	6,609,158	
1863	3,896,600	4,645,272	
1864	440,445	734,924	
1865	none (*t*)	20,126	
1866	62,690	67,662	
1867	3,991,010	2,943.512	
1868	5,735,735	6,474,760	
1869	1,844 485	2,040,578	
1870 (*u*)	74,955	213.402	
1871	2,323,345	1,817,694	205,100
1872	4,338,640	4,722,084	121,650 (*w*)
1873 (*v*)	2.500,000	2,543,588	

(*q*). In 1833 the Nile failed to overflow its banks, the harvest was greatly deficient, famine ensued and grain rose to a high price; nevertheless prices were still higher on the Black Sea, and Mehemet Ali, turning a deaf ear to the sufferings of his own people, sent 60,000 ardebs thither for sale.—MacGreggor.

(*r*). In 1841 the exports of wheat from Egypt were mainly to Italy and Turkey. The British trade did not spring up until after this date.

(*s*). In 1855 the exports of wheat were 5,573,070 bushels to Great Britain; 652,205 to France; 137,900 to Austria and 2,011,085 to other countries.

(*t*). In 1865, failure of grain crops. Exports of grain prohibited until July 31, 1866.

(*u*). In 1870, failure of grain crops. Exports of grain other than wheat: Rice 100,625, Maize 6,895 and Barley 170,265 bushels.

(*v*). Wheat shipped from Alexandria to United Kingdom 1862 to 1872 inclusive, 29,-352,260 bushels at five to the ardeb. Total received in United Kingdom during same period 30,289,172 bushels of 56 lbs. each—a substantial agreement.

(*w*). 18.2. Also 58,855 bushels to Italy.

No wheat is permitted to be shipped from Egypt without paying to the government an export-duty of about 37½ cents per bushel, and no laborer is permitted to leave the country at all; so that the conditions of her industry are in a certain sense fixed.—MacGreggor.

The Future of Egypt.

Apart from the subject of her agricultural and commercial *rivalry* with the United States, Egypt possesses an interest to us which I trust will furnish ample apology for the uncomplimentary terms in which I have found it necessary to advert to her government, or what is the same thing, the Khédive. Rulers have difficulties to contend with which are not always readily appreciated by others, and doubtless the Khédive has his share of them. He sees beneath him a country which demands incessant labor for its cultivation; a people, ignorant, superstitious and, as he believes, slow and lazy. His administration, bad as it seems to us, has nevertheless been one of peace, and wholly unstained by the barbarous cruelties that distinguished those of Mehemet Ali and Ibrahim and Abbas Pasha. But although, to use the expression of the illustrious Turgot with reference to the finance system of France under the reign of Louis XV., the Khédive has not "killed the goose that lays the golden eggs," he has plucked it to the bone.

Were this potentate once to reflect how little glory there is in such a course, and how many millions of suffering human creatures would bless him now and his name forever, did he change it; were he but to consider how infinitely more creditable in the eyes of the world, and more gracious in the sight of the God and the Prophet he worships would appear his devotion to the amelioration of the condition of his people, than the amassment of wealth and the building of palaces in which he is engaged, it is perhaps not too much to say that he would adopt a wholly different national policy.

That this may be the case, and Egypt afforded an opportunity to rise once more among the nations of earth—not as a land merely of archæological remains, but as the abode of a numerous and prosperous people—cannot but be the fervent wish, not only of all Americans, but of the modern world at large.

LIST OF THE NORTH AMERICAN PLATYPTERICES, ATTACI, HEMILEUCINI, CERATOCAMPADÆ, LACHNEIDES, TEREDINES AND HEPIALI, WITH NOTES

By Aug. R. Grote.

(*Read before the American Philosophical Society, Nov. 20th,* 1874.)

In this list, I present the results of my studies on a portion of the North American Bombyces. The admirable synopsis of the Family by Dr. Packard, I have found our best authority on the subject, while I have been able to propose many necessary and important changes in nomenclature from more extended bibliographical researches. The only changes from Dr. Packard's classification here made, are the division of the "Hepiali" into two groups, in which I follow Hübner, and the disintegration of the "Ceratocampadæ" into Hemileucini and Ceratocampadæ indicated by Mr. Robinson and myself in 1866. To Mr. S. H. Scudder we owe the reprinting of the Tentamen of Hübner and, more recently, the discovery of the exact date* (1806) of that valuable document.

In the present List, a star (*) is prefixed where the genus is represented in Europe; a dagger (†) where I have been unable to examine the species myself.

Bombyces Linn. (1788). *Bombyces* Borkh., 1798; *Bombyces* Hübn., 1806; *Bombycites and Noctuo-Bombycites* Latr., 1810; *Phalaenæ* Hübn., 1816.

PLATYPTERICES Hübner (1806).

Platyptericidæ Stephens, 1829; *Platypteryginæ* Grote, 1868.

* Platypteryx Laspeyres (1802).

Type: Bombyx hamula *S. V.*

Note.—Hübner, in his Tentamen, first restricts Laspeyre's generic term to this type. Since Schrank's genus *Drepana* (1801), contains species not congeneric with this type, his name, while earlier, must be used for one of these, and Hübner's restriction of Laspeyre's later term must be respected according to the rules of Zoological nomenclature. This restores my original determination (1862) for our American species. Stephens' "Drepana fasciata," is probably a species of *Drepanodes*, from the description.

siculifer (Pack.), 4th Ann Rep. Peab. Acad. Sci., 87 (*Drepana*); *id.* Stretch, Zyg. Bomb. N. Am., 110, Pl. 4, fig. 11. California.

arcuata (Walk.), C. B. M., 5, 1164 (*Drepana*); *Platypteryx arcuata* Grote, Proc. Acad. N. Sci. Phila., 1862, p. 360; *Plat. fabula* Grote, l. c., p. 59. Canada to Middle States.

genicula (Grote), Proc. Acad. N. Sci. Phila., 1862, p. 59. Canada to Middle States.

* See Hübner, Zutr., 1. S. 4.

* PRIONIA Hübner (1816).

Type: Phalæna lacertinaria *Linn.*

bilineata (Pack.), Proc. Ent. Soc. Phila., 3, 376 (*Edapteryx*) Pl. 6, fig. 9. Eastern and Middle States.

NOTE.—Stephens' later restriction of *Platypteryx* for this genus cannot be followed. Möschler, from figures, regards our species as identical with the European. Stett. Ent. Zeit., 251, 1871.

DRYOPTERIS Grote (1862).

Type: Platypteryx formula *Grote.*

rosea (Walk.), C. B. M., 5, 1164 (*Drepana*); *Drepana marginata* Walk., l. c., 1165; *Cilix Americana* H. S, Lep. Exot., 470; *Platypteryx formula* Grote, Proc. Acad. N. Sci., Phila., 1862, 60; *Dryopteris rosea* Grote, l. c., 360. Canada to Virginia.

irrorata Pack., Proc. Ent. Soc., Phila., 3, 377. Eastern States.

ATTACI Linn. (1788).

NOTE.—This sub-family is indicated by Linné under the name "Attacos," Ed. xiii, Syst. Nat., p, 2401. *Echidnæ* Hübn., and *Heræa* Hübn., must both be considered synonymous. The type of *Echidna* (1805), is *E. Tau;* the type of *Heræa* (1806), is *H. Carpini.*

ACTIAS Leach (1815).

Type: Phalæna Luna *Linn.*

Luna (Linn.), Syst. Nat. Ed. 10, 1, 496, No. 5 (1758); id. Ed. 12, 810, No. 5 (1767); id. Mus. Ulr., 368, No. 5 (1764); Abb. & Sm. Ins. Ga., 1, 95, T. 48; Leach, Edin. Encyc., 9 (1815), (*Actias*); Hübn., Verz., 152, No. 1587 (*Tropæa*). Canada to Alabama; double brooded in Alabama, where it readily flies in the day time.

NOTE.—The Plate of this species Band 2, Exot. Schm., is wrongly dated "1806" by Packard. It is later than the Verzeichniss. In a letter dated 29th Sept., 1866, Dr. Herrich-Schæffer gave the following dates to the 3d vol. of the Sammlung; "*Casiphone* to *huntera*, 1828; *Asclepias* to *rustica*, 1829; *Io* to *taygete*, 1830; *pasithæ*, *grimmia*, 1831; *crista* to *beltrao*, 1832; *nesea* to *thirza*, 1833; *debora-hylas*, 1834; *lusca-huebneri*, 1835."

TELEA Hübn. (1816).

Type: Bombyx polyphemus *Cramer.*

Polyphemus (Cram.), 1, Pl. 5, A. B.; Fabr., Sp. Ins., 2, 168, No. 5; Mant., 2, 108, No. 6; Linn., Syst. Nat. Ed., 13, p. 2402, No. 461; Fabr., Syst. Ent., 410, No. 8; Abb. & Sm., 93, T. 47; *Telea polyphemus* Hübn., Verz., 154, No. 1610; *Bombyx Paphia*‡ Linn., Mus. Ulr. (1764), p. 369, No. 4, (not S. N. 10, 1758, see Am. Naturalist); *Telea Paphia* Kirby, Trans. R. Dub. Soc., 203 (1872). Canada to Mexico; California.

ATTACUS Linné.

Type: Attacus Atlas *Linné.*

† **splendidus** (De Beauv.), His. Afr. Am., 133, Pl. 22, fig. 1, 2 (*Bombix*); Clem., Proc. Acad. N. S., Phila. (1860), p. 160, (*Attacus*). Texas.

PHILOSAMIA Grote (1874).

Type: Phalæna Cynthia *Drury*.

NOTE.—Mr. W. F. Kirby, has drawn attention to the fact that after Walker's restriction of the genus *Samia*, in 1855, to *cecropia* and *promethea*, the term could not be used again for Hübner's *Samia cynthia*. The term *Platysamia* must then be dropped and a new name be used for the present genus, hitherto confounded with *Attacus*, and described by me in 1865 under the name *Samia*. To *Philosamia* belong the Asiatic species, *lunula*, *ricini*, *Cumingii* and *Guerini*.

Cynthia (Drury), Ill., 2, 10, Pl. 6, fig. 2; Hübn., Verz., p. 156, No. 1629 (*Samia*); Grote, Proc. Ent. Soc., Phila., 5, 228 (*Samia*).

NOTE.—With the usual latitude for coarseness and infidelity of coloring, I think Cramer's figures under this name represent the same species.

Brooklyn, L. I.; Philadelphia; Baltimore. Introduced and apparently acclimated with us.

CALLOSAMIA Packard (1864).

Type: Bombyx Promethea *Drury*.

Promethea (Drury), Ill. 2, Pl. 12, fig. 1. 2, ♀; Abb. & Smith, His. Ga., 91, T. 46; *Samia Promethea* Hübn., Verz., p. 156, No. 1631; *Callosamia Promethea* Pack., Proc. Ent. Soc., Phila., 3, 379. Canada to Alabama.

NOTE.—In the original perfect copies of Drury, an Index, with names according to the Linnean system, is given at the end of each volume.

angulifera (Walk.), C. B. M., 5, 1224 (*Samia*); Pack., Proc. Ent. Soc., Phila., 3, 380 (*Callosamia*). New York; Pennsylvania.

SAMIA Hübner (1816).

Type: Phalæna Cecropia *Linn.*

Cecropia (Linn.), Syst. Nat. Ed. 10, 1, 496, No. 3; *id.* Ed. 12, 809, No. 3; Mus. Ulr., 368, No. 3; Abb. & Sm., His. Ga., 89, T. 45; *Samia Cecropia* Hübn., Verzeich., 156, No. 1630; *Platysamia Cecropia* Grote, Proc. Ent. Soc., Phila., 5, 229. Canada to Alabama.

† **Columbia** (S. I. Smith), Proc. Bost. Soc. N. Hist., 9, 343. Canada; Eastern States.

† **Gloveri** (Strecker), Lep. Rhop. Het., No. 1, Plate (*Platysamia*). Arizona.

Californica (Grote), Proc. Ent. Soc., Phila., 5, 229 (*Platysamia*); W. F. Kirby, Proc. Roy. Dub. Soc., 1872, 202 (*Samia*); "*Saturnia ceanothi*, Beer," Boisd. Ann. Soc. Ent. Belg., 12, 83.

NOTE.—No description of this species under the names "*Euryalus*" or "*ceanothi*" is known to us previous to Dec., 1865, the date of its description as *Californica*.

California.

* SATURNIA Schrank (1801).

Type: Phalæna pavonia major *Linn.*

† **Galbina** Clem., Proc. Acad. N. S., Phila., 1860, p. 156. Texas.

HEMILEUCINI Grote and Robinson (1866).

NOTE.—This group, which we would consider as of sub-family value, is discussed in Ann. Lyc. Nat. Hist., N. Y. 8, pp. 377, 378. None of the collective names proposed by Hübner can be used. The group is not recognized in the Tentamen (1806); in the Verzeichniss some of the genera are referred to the *Echidnæ*, and one to the *Heræa*, names explained above under *Attaci*.

AUTOMERIS Hübn. (1816).

Type: Bombyx Janus *Cramer*.

Io (Fabr.), Ent. Syst. p. 419, No. 37; Abb. & Sm., Ins. Ga., p. 97, T. 49; Harr. Cat. Ins., Mass. (*Saturnia*); Hübn., Samm. Exot. Sch., 3, figs. 1, 2, ♂, 3, 4, ♀ (*Hyperchiria*); *Hyp. varia* Walk., C. B. M., 6, p. 1278. Canada to Southern States.

NOTE.—This generic term has priority in the Verzeichniss. Cramer's figures under this specific name cannot, by themselves, constitute a valid priority.

Zelleri (G. & R.), Trans. Am. Ent. Soc., Phila., 2, Pl. 2, fig. 65 (*Hyperchiria*). Texas.

COLORADIA Blake (1863).

Type: Coloradia Pandora *Blake*.

NOTE.—This genus is distinct from Dirphia *Hubn.* (1816), the type of which is D. Tarquinius (*Cram*).

Pandora Blake, Proc. Ent. Soc., Phila., 2, 279, Pl. 7. Colorado Territory.

PSEUDOHAZIS G. & R (1866).

Type: Saturnia eglanterina *Boisd.*

NOTE.—Dr. Packard's genus *Eucronia* is founded on H. maja, which we have shown to be Walker's type of Hemileuca. In an opposite view, the validity of the present generic name cannot be disputed until it is satisfactorily shown that the South American *H. venosa* Walk., is congeneric.

Hera (Harr.), Rep. Ins. Inj., Mass., 286, 1841 (*Saturnia*); *Saturnia eglanterina* Boisd., Ann. Soc. Ent. Fr. 2 Ser., 10, 323; *Telea eglanterina* H.-S., Exot., 60, 445; *Pseudohazis Hera* G. & R., Ann. Lyc. N. Hist., N. Y., 8, 377. California; Rocky Mountains.

HEMILEUCA Walk (1855).

Type: Phalæna Maja *Drury*.

Maja (Drury), Ill. 2, 42, Pl. 24, fig, 3; *Bombyx Proserpina* Fabr., Ent. Syst., 561, No. 17; *id.* Abb. & Sm., Ins. Ga., Pl. 50; Walk., C. B. M, 6, 1317 (*Hemileuca*). Mass. to Georgia, Westward to Illinois.

† **Nevadensis** Stretch, Zyg. Bomb. N. Am., 108, Pl. 4, fig. 10. Nevada.

Grotei Hopffer, Trans. Am. Ent. Soc., 2, 192, Pl. 2, fig. 60. Texas.

† **Juno** Pack., 4th Ann. Rep. Peab. Acad. Sci., 87. Arizona.

† **pica** Walk., C. B M., 6, 1318 (*Hemileuca*); G. & R., Trans. Am. Ent. Soc., 2, 74 (*Pseudohazis*). "United States."

EULEUCOPHÆUS Pack. (1872).

Type: Euleuc. tricolor *Pack.*

tricolor Pack., 4th Ann. Rep. Peab. Acad. Sci., 89; Stretch, Zyg. Bomb. N. Am., 143, Pl. 6, figs. 3. 4. New Mexico.

CERATOCAMPADÆ Harris (1841).

NOTE.—This appears to be the earliest collective term that can be used for this group. The genera are partly referred by Hübn. in 1816, to his *Echidnæ* (see *ante*), and partly to his *Trichodæ*. The type of *Trichoda* (1806) is, however, a Lachneid, a designation which has the priority by a line in 1806.

EACLES Hübn. (1816).

Type: Bombyx imperialis *Drury.*

imperialis (Drury), 1, 17, Pl. 9, figs. 1, 2; *Phalæna imperatoria* Abb. & Sm., Ins. Ga., 109, T. 55; Hübn., Verz., 153, No. 1602 (*Eacles*); *Bombyx didyma* De Beauv., Ins. Afr. Am., pp. 51, 52, Pl. 20, figs. 1, 2 (1806). Eastern States, Southward. Appears to be replaced in Brazil by E. magnifica *Walk.*

CITHERONIA Hübn. (1816).

Type: Bombyx regalis *Fabr.*

regalis (Fabr.), Syst. Ent., 436, No. 93; *Phalæna regia* Abb. & Sm., 2, 121, Pl. 61; Hübn., Verz., 153, No. 1599 (*Citheronia*); *Phalæna Laocoon* ‡ Stoll (*nec Cramer*) Supp. pp. 179, 180, Pl. 42, fig. 2, ♂; *Eacles Laocoon*, Walk., C. B. M., 6, 1732. Massachusetts to Georgia. Appears to be replaced in Mexico by C. mexicana *G. & R.*

sepulcralis G. & R., Proc. Ent. Soc., Phila., 4, p. 222; Ann. Lyc. N. H., N. Y., 8, p. 382, Pl. 12, figs. 2, 3. Massachusetts to Georgia. This species is represented on one of Abbot's unpublished Plates in the British Museum Collection.

SPHINGICAMPA Walsh (1864).

Type: Sphingicampa distigma *Walsh.*

bicolor (Harr.), Rep. Ins. Inj. Veg., Mass., 203 (1841) *Dryocampa*; Walsh, Proc. Bost. Soc. N. Hist., 1864, p. 293 ♀; *Sphingicampa distigma*, Walsh, l. c. p. 290 ♀ ♂; *Sphing. bicolor* Grote, Soc. Ent. Belg. Comptes Rendus (1874). North Carolina; Illinois; New York.

ANISOTA Hübn. (1816).

Type: Bombyx stigma *Fabr.*

stigma (Fabr.), Ent. Syst., 424, No 54; Abb. & Sm., Ins. Ga., 111, T. 56; Hübn., Verzeichniss, 193, No. 1978 (*Anisota*); Grote, Proc. Ent. Soc., Phila., 3, 93 (*Anisota*). Massachusetts to Georgia.

senatoria (Abb. & Sm.), Ins. Ga., 113, T. 57; Hübn., Verz., 193, No. 1979 (*Anisota*); Harr., Rep. Ins. Mass., 3d Ed., 406, figs. 199, 200 (*Dryocampa*); Grote, Proc. Ent. Soc., Phila., 3, 93 (*Anisota*). Canada to Georgia.

Virginiensis (Drury), Ill., 2, 23, Pl. 13, fig. 2, (*Bombyx*); *Phalæna pellucida* Abb. & Sm., Ins. Ga., 115, T. 58; *Anisota virginiensis* Pack., Proc. Ent. Soc., Phila., 3, 385. Massachusetts to Georgia.

DRYOCAMPA Harris (1835).

Type: Bombyx rubicunda *Fabr.*

rubicunda (Fabr.), Ent. Syst., 429, No. 69; Harr. Cat. Ins., Mass. 72, (*Dryocampa*); Rep. Ins. Inj. Veg. Mass., 3d Ed., 408, fig. 201. Canada to Virginia.

var. **alba** Grote, Bull. Buff. S. N. S., 2, 153. Kansas.

LACHNEIDES Hübn. (1806).

[*Bombycidæ* Stephens (p.), 1829.]
[*Lasiocampidæ* Duponchel (p.), 1846.]

NOTE.—The adoption of this name by Dr. Packard in 1868, must now be followed. It is the earliest title for any part of the sub-family that we are able to find. The type of the genus *Lachneis* is the European *Lachneis Cataæ*.

GLOVERIA Pack. (1872).

Type: Gloveria Arizonensis *Pack.*

† **Arizonensis** Pack., 4th Rep. Peab. Acad. Sci., p. 90 (1872). Arizona.

* EUTRICHA Hübner (1806).

Type: Bombyx quercifolia *Linn.*

Americana (Harr.), Rt. Ins. Inj. Veg., p. 273; *id.* 3d Ed., p. 377, fig. 176 (*Gastropacha*). Maine to Pennsylvania.

† **ferruginea** (Pack.), Proc. Ent. Soc., Phila., 3, p. 386 (*Gastropacha*). Michigan.

† **carpinifolia** (Boisd.), Ann. Soc. Ent. Belg., 12, p. 83 (*Lasiocampa*). California.

† **Californica** (Pack.), 4th Rep. Peab. Acad. Sci., p. 91 (*Gastropacha*). South California.

† **Mildei** (Stretch), Zyg. and Bomb. N. A., p. 113, Plate 4, fig, 12 (*Gastropacha*). California.

NOTE.—The American species seem to need revision. Dr. Packard informs me that the memoir in which "*alascensis*" was described is no longer extant, the edition having been destroyed in the great fire at Chicago.

* TRICHODA Hübner (1806).

Type: Bombyx neustria *Linn.*

Americana (Fabr.), Ent. Syst., 3, p. 433, No. 81; Harris Rep. Ins. Inj. Veg., p. 269 (*Clisiocampa*); *id.* 3d Ed., Pl. 7, figs. 13, 17; *Cl. decipiens*, Walk., C. B. M., 6, 1488; castrensis ‡ Abb. & Sm., p. 119, T. 60; *Bombyx frutetorum* Boisd., Ann. S. E. Belg., 12, 82. Canada to Georgia.

disstria (Hübn.), Verz., p. 192, No. 1975 (*Malacosoma*); neustria ‡ Abb. & Sm., p. 117, T. 59; *Clisiocampa silvatica* Harr., Cat. Ins. Mass., 72; Rep. Ins. Inj. Veg., 271; *id.* 3d Ed., p. 376, Pl. 7, fig. 18, 19; *Bombyx drupacearum* Boisd., Ann. Soc. Ent. Belg., 12, p. 82. Canada to Georgia.

Californica (Pack.), Proc. Ent. Soc., Phila., 3, p. 387 (*Clisiocampa*); *Bombyx pseudoneustria* Boisd., Ann. Soc. Ent. Belg., 12, 82. California.

ARTACE Walk. (1855).

Type: Artace punctistriga *Walk.*

punctistriga Walk., C. B. M., 7, p. 1491. New York to Georgia.

TOLYPE Hübner (1816).

Type: Bombyx Velleda *Stoll.*

Velleda (Stoll), Supp. Cram., p. 178, Pl. 41, fig. 4; Hübn., Verz., S. 189, No. 1943 (*Tolype*). Canada to Georgia.

Laricis (Fitch), 2d N. Y. Rep. p. 262, Pl. 2, fig. 5 ♂, 6 ♀ (*Planosa*). *Gastr. minuta* Grote, Proc. Ent. Soc., Phila., 2, p. 433 ♂.

NOTE.—Fitch's description and figure of the ♂ were probably taken from rubbed specimens.

HETEROPACHA Harvey (1874).

Type: Heteropacha Rileyana *Harvey.*

Rileyana Harvey. Bull. Buff. Soc., N. S, 1, p. 263, Pl. 11, fig. 1. Missouri; Texas (Boll. in M. C. Z. Cam.).

NOTE.—Dr. Harvey's type is somewhat rubbed. Fresh specimens show the fringes distinctly chequered, fuscous and whitish. On the forewings the median space is darker, confined by dark lines indistinctly edged with whitish. Terminally the wing is more whitish, showing the subterminal spots plainly.

TEREDINES Hübner (1806).

[Cossides *Herr.-Sch.*, 1845.]

NOTE.—This and the following group are equivalent to the "*fodicantes*" of Hübner (1806). We would consider them of equal value. The European *T. Cossus* (Linn.) is made the type of the genus *Teredo*, by Hübner, in the Tentamen. In v. Heineman's extremely unsatisfactory arrangement of the Bombyces, the genus *Limacodes* is associated with this group.

XYSTUS Grote (1874).

Type: Cossus robiniæ *Peck.*

Note.—The name *Xyleutes* of Hübner, cannot be used for this genus, for the reason that it is originally applied to none of the species; in the Verzeichniss it appears to be used instead of *Teredo* (Tentamen) for the European *Teredo cossus* (Linn.). Gr.: ξυστός.

Robiniæ (Peck), Mass. Ag. Rep. Journ., 5, 67 (1818), Plate (*Cossus*); *Harris*, Rt. Ins. Inj. Veg., Mass., 297 (*Xyleutes*); H.-S., Lep. Ex., figs. 170, 171. Canada; Eastern and Middle States; California?

† **crepera** (Harr.), Cat. Ins., Mass., p. 72 (*Cossus*); *Xyleutes crepera* Pack., Proc. Ent. Soc., Phila., 3. p. 388. Massachusetts.

† **querciperda** (Fitch), 5th Rep. Nox. Ins., N. Y., p. 10 (*Cossus*); Pack., Proc. Ent. Soc., Phila., 3, p. 389 (*Xyleutes*). New York.

† **Mac Murtrei** (Boisd.), Icon. Régne. An., Pl. 85, fig. 2 (*Cossus*); *Cossus plagiatus* Walk., Cat. B. M., 7, p. 1515. United States.

† **Populi** (Walk.), C. B. M., 7, p. 1515 (*Cossus*); Pack., Proc. Ent. Soc. Phila., 3, 389 (*Xyleutes*). Hudson's Bay Territory.

NOTE.—A single species is known from Cuba, *Xystus piger* (Grote), Proc. Ent. Soc. Phila., 5, 254 (*Xyleutes*).

* ZEUZERA Latreille (1805).

Type : Bombyx æsculi *Linn.*

† **pyrina** (Fabr.), Ent. Syst., 3, p. 5, No. 6 (*Cossus*); Walk., C. B. M., 7, p. 1530 (*Zeuzera*). North America.

† **Canadensis** H.-S., Lep. Exot. Sp. N. aut In., S. 58, fig. 168; Walk., C. B. M., 7, 1530. Canada (Quebec).

HEPIALI Linn. (1788).

[Hepioli *Hübn.*, 1806.]

NOTE.—This sub-family is indicated by Linné, under the name "Hapiali," Ed. xiii, Syst. Nat., p. 2402.

* HEPIALUS Fabr. (1793).

Type : Noctua humuli *Linn.*

NOTE.—The type of this genus is the European *humuli*, indicated by Hübner in the Tentamen, 1806. Following Dr. Packard's remarks, our species, though occasionally of increased size, do not differ generically.

argenteomaculatus Harr., Cat. Ins., Mass., p. 72; Rep. Ins. Inj. Veg., p. 295; *id.* 3d Ed., p. 410, *partim.* Non alior. Eastern States; Catskill Mts. (Mead.); Pennsylvania (Coll. Am. Ent. Soc., Phila.)

NOTE.—This and the following species have been confounded by Harris and Packard.

quadrigattatus (Grote), Proc. Ent. Soc., Phila., 3, p. 73, Pl. 1, fig. 6 (*Gorgopis*); *Hep. arg.* ‡ Harris, Agassiz, Lake Superior, 389, Pl. 7, fig. 6; *id.* Rep. Ins. Inj. Veg., 3d Ed., p. 410 (foot note), fig. 202; *id.* Walk., *var.* C. B. M., 7, 1556; *Sthenopis arg.* ‡ Pack., Proc. E. S., Phila., 3, 392. Great Slave Lake; Lake Superior; Quebec (Bélanger); Saskatchewan.

NOTE.—This is a larger, more pinkish, salmon-colored species, with smaller dots.

† **purpurascens** (Pack.), Journ. Bost. Sec. Nat. Hist., p. 598 (*Gorgopis*); Pack., Proc. Ent. Soc., Phila., 3, p. 392 (*Sthenopis*). White Mountains, N. Hamp.

† **argentatus** (Pack.), Proc. Ent. Soc., Phila., 3, 392 (*Sthenopis*). Massachusetts.

NOTE.—This is perhaps the true *H. argenteomaculatus*, as separated by myself. Harris first notices apply to an Eastern species.

† **Behrensii** (Stretch), Zyg. Bomb. N. A., 1, 105, Pl. 4, fig. 6 (*Sthenopis*). California.

† **montanus** (Stretch), Zyg. Bomb. N. A., 1, 105, Pl. 4, fig. 7 (*Sthenopis*). California, (Sierra Nevada).

hyperboreus Mösch., W. E. M., 6, 129 (*Epialus*), Taf. 1, fig. 1; *Hep. pulcher* Grote, Proc. Ent. Soc., Phila., 3, p. 522, Pl. 5, fig. 3. Labrador; Colorado Territory.

† **Labradoriensis** Pack., Proc. Ent. Soc., Phila., 3, p. 394. Labrador.

† **mustelinus** Pack., Proc. Ent. Soc., Phila., 3, 393. Eastern States.

gracilis Grote, Proc. Ent. Soc., Phila., 3, p. 522, Pl. 5, fig. 4. Quebec.

† **Californicus** Boisd., Ann. Soc. Ent. Belg., 12, p. 85. California.

† **hectoides** Boisd., Ann. Soc. Ent. Belg., 12, p. 85. California.

RESULTS OF AN EXAMINATION OF AN EXPLODED LOCOMOTIVE BOILER, AND OF EXPERIMENTS TO ASCERTAIN THE CAUSES OF EXPLOSION.

BY DR. CHARLES M. CRESSON.

(*Read before the American Philosophical Society, July* 17, 1874.)

The boiler was constructed of No. 1 ($\frac{5}{16}$) boiler iron, single riveted (with the exception of the junction of the waist with the fire-box, which was double riveted); it was of the ordinary locomotive form with enlarged grate surface adapting it for use with Anthracite fuel.

The fire-box had the ordinary flat crown sheet suspended from wrought iron girders by means of bolts $\frac{3}{4}$ in. in diameter, placed $4\frac{1}{2}$ in. apart, the ends of the girders being supported upon the vertical sides of the fire-box. The vertical sheets of the fire-box were stayed by wrought iron bolts $\frac{7}{8}$ in. in diameter, placed 4 in. apart, screwed into the sheets and riveted at the end.

The crown sheet and that part of the boiler directly over the fire-box were connected by stay-rods.

The engine had been run upon a siding to pull out a train of cars, which train being heavier than was ordinarily pulled, the steam-blower was applied for the purpose of increasing the intensity of the fire and generating steam of a higher pressure than was usually employed. But when preparations for starting were completed, it was found, upon refer-

ence to the time-table, that the engine would have to remain upon the siding until an expected passenger train had passed. The engineer then left the engine, having first stopped off the steam-blower and observed a steam pressure of about 90 lbs. per square inch.

The boiler exploded between ten and twenty minutes after the engineer had left it. The fireman, who had been cleaning the valves of the sand-box, was at work upon the engine when the explosion took place, and when last seen was standing upon the left side of the engine near the donkey-pump, which was used to supply the boiler with water when the engine was upon the siding. The portion of the boiler immediately over and back of the crown-sheets of the fire-box, and including the back dome, was blown off bodily, the line of fracture passing indiscriminately through the seams and across the sheets.

The seams not torn apart were strained in some places as much as $\frac{1}{4}$ of an inch and opened. The fire-box was blown backwards, carrying with it the back tube-sheet. The remaining portion of the waist of the boiler and the engine were driven forward along the track, the tubes remaining fast in the forward tube-sheet. An examination of the fire-box showed the crown-sheet to have been forced violently downwards, one edge crushing the side-sheets of the fire-box, the other edge and the ends of the crown-sheet remaining nearly in place.

Every stay that was displaced was either fairly broken or drawn through the sheets. There were no signs of undue pressure upon any joint or part of the remaining waist of the boiler, excepting at the line of rupture.

The iron in every part of the boiler appeared in good condition, without signs of burning or heating, except in one lower corner of the fire-box, which part, however, was not ruptured or affected by the explosion. Trial pieces of the iron cut from several parts of the fire-box and waist-sheets exhibited good fracture, the lowest tensile strength found was 51,000 lbs. to the square inch.

After a careful examination of the wreck, and of the results of my own experience, I have arrived at the conclusion that the explosion of this boiler was caused by the projection of water upon the heated crown sheet. The crown-sheet of the furnace was most probably heated to a temperature of between 500° and 600° Ft., in consequence of a neglect to keep the water in the boiler at the proper height.

This temperature, not sufficient to produce a spheroidal state of the water thrown upon the crown-sheet, allowed of enough heat to be stored up and given out suddenly to cause steam of very high pressure to be instantly generated, so that the rear portion of the boiler was blown to pieces before a sufficient time had elapsed to allow of the distribution of the expansive force throughout the waist. By reference to the results of experiments detailed in the following paragraphs, it will be seen that an average of $\frac{23}{100}$ of an inch of depth of water over the crown-sheet could readily be converted into steam in one second of time, and would produce

a pressure of over 570 lbs. per square inch in addition to that already existing in the boiler.

The sudden opening of any outlet of pressure, such as the safety-valve, throttle, whistle, blower or steam-cock to the donkey-pump, would produce a foaming or disturbance of the water-level in the water-space surrounding the fire-box, causing the water to flow over the crown-sheet in an amount quite sufficient to account for the disaster under the conditions indicated.

To illustrate the rapidity of the explosive force, let us suppose the upper surface of the crown-sheet of the fire-box to have been covered with gunpowder to a depth equal to that of the water, which we have shown could have been evaporated by it. If this powder were ignited in the ordinary way, it would require from half a second to two seconds for its complete combustion, according to the quality of the powder, whereas an equal quantity of water thrown upon the crown-sheet could be converted into steam in less than one second, the resulting volume of vapor being nearly equal in both cases.

Careful examination of the quality of the iron, and of the plan of construction of the boiler, have convinced me that the boiler was amply strong for the purposes designed. I am of the opinion that the disaster occurred directly and solely from a neglect to keep the water within the boiler at its proper level.

The tests and experiments made, upon which the foregoing opinion was founded, are as follows :

A.—Tests of Strength of Iron.

Test pieces cut from the worst looking part of the side-sheet of the fire-box gave the following results :

a.—With the length of the sheet. Dimensions of breaking section :

Thickness	0.302	inch.
Width	0.402	"
Original length of piece	2.800	"
After fracture	2.943	"
Length of section extended	1.000	"
Extension	0.143	"
Breaking wt. per sq. in	54,300	lbs.

b —Cut across the sheet. Dimensions of breaking section :

Thickness	0.308	inch.
Width	0.409	"
Original length of piece	2.790	"
After fracture	2.890	"
Extension	0.100	"
Breaking wt. per sq. in	51,200	lbs.
Length of section extended	1.000	inch.

B.—Experiments Upon Hot Plates.

The sampl s employed were cut from the crown-sheet bars of the exploded boiler. To ascertain their specific heat, and the amount of heat they were capable of imparting to water in a given time, the samples were heated in a mercury bath at various temperatures, and then plunged into a weighed amount of water and the rise of temperature carefully ascertained by a thermometer graduated to $\frac{1}{10}$° Ft.

To ascertain the amount of heat imparted by the iron in a given time, the samples were immersed by securing them to a cross-arm fixed to a heavy pendulum of such length as to vibrate in the desired time and averaging the results of many observations.

As these experiments were to ascertain the lowest probable capacity of the iron in the crown-sheet for storing and giving out heat, no great care was taken to prevent radiation of heat from the iron in its passage from the mercury bath to the water, nor of radiation from the water bath during the experiment; the results do not, therefore, by any means, express the full amount of heat to be derived from the samples.

Calculations of the amount of steam generated in a given time by iron under the conditions stated, must therefore fall short of the practical effect produced, and if the conditions assumed for experiment show that steam could have been generated in sufficient quantity and with sufficient rapidity to have destroyed the boiler, we can safely conclude that the actual destructive effect was greater than that expressed by our results.

The specific heat of iron is given in the tables at an average of 0.1200 that is, that eight times as much heat is required to raise one pound of water through a given number of degrees as will suffice to raise one pound of iron through a similar number of degrees. For example, 8 lbs. of iron losing 100° Ft. of temperature will elevate the temperature of 1 lb. of water 100° Ft. By the formula:

$$\frac{\text{Wt. of Water}\left(\begin{matrix}\text{Temp. of Water}\\ \text{before immersion}\end{matrix}-\begin{matrix}\text{Temp. of Water}\\ \text{after immersion}\end{matrix}\right)}{\text{Wt. of Iron}\left(\begin{matrix}\text{Temp. of Iron}\\ \text{before immersion}\end{matrix}-\begin{matrix}\text{Temp. of Iron}\\ \text{after immersion}\end{matrix}\right)}=\text{S. H.}$$

I have determined the specific heat of the sample of iron cut from the boiler to be 0.113 at a temperature of 212° Ft., and as it is considerably greater at higher temperatures, I have therefore assumed it to average $\frac{1}{8}$ that of water.

Experiments made with gunpowder to ascertain the rapidity of explosion, showed that with various kinds of gunpowder the time required for complete ignition of a thin stratum of powder, spread over a surface equal to the area of the crown-sheet, when ignited at one edge only, varied from one-quarter of a second to one and a half seconds; and as the destructive effects are most impressive to the popular mind, they serve to illustrate the effects that can be produced by converting water into steam as the increase in volume is about the same, that is, 1700 volumes of vapor are

produced by the combustion of gunpowder, and 1700 volumes of vapor of atmospheric tension are generated by the conversion of water into steam.

The experiments alluded to of immersing a sample of the iron whilst heated into water, were made chiefly with a sample weighing 2,914 grains heated to a temperature of 500°@520° Ft., and immersed in a body of water weighing 29,140 grains (ten times the weight of the iron). Some of the results were as follows :

Time of immersion	1 second.
Expt. No. 1, rise of temp. of water	2.9° Ft.
" " 2, " " "	2.7° "
" " 3, " " "	2.8° "
" " 4, " " "	2.8° "
" " 5, " " "	2.7° "
" " 6, " " "	2.8° "
" " 7, " " "	2.9° "
" " 8, " " "	2.9° "
" " 9, " " "	2.7° "
Average	2.8° Ft.

Or 2,914 grains of iron were capable of imparting 28° Ft. to an equal weight of water in one second of time.

The weight of the crown-sheet was	300 lbs.
Bars and studs attached was	810 "
Total	1110 lbs.

This mass of iron could therefore impart 28° Ft. to 1110 lbs. of water in one second of time, or could have converted 32 lbs. of water into steam.

For an example, let us suppose the crown-sheet and bars to have been heated to a temperature of 514° Ft., and that we have flowed over it an amount of water sufficient to reduce the temperature of the iron to 423° Ft., corresponding to a pressure of steam of 300 lbs. to the square inch, and which suddenly added to the pressure already existing in the boiler must severely try the boiler, if not tear it apart.

Then, Temp. of Iron	514° Ft.
Reduced to	423° Ft.
Fall of temperature	91° Ft.

Then $1,110 \times 91 = 101,010$ units of heat given out by the iron; this divided by $8 = 12,626$ lbs. of water heated 1° Ft., and this divided by the latent heat of steam at 423° Ft, plus the difference between the sensible heat at 90 lbs. and at 300 lbs. = 913, gives 13.8 lbs. of water as the amount converted into steam at 300 lbs. pressure.

The area of the crown-sheet=22 sq ft. this amount of water (13.8 lbs.) would cover it to a depth of 0.12 inches, and when expanded into steam of one atmosphere of tension would occupy a space equal to a prism having the crown-sheet for its base and 204 inches in height. The aver-

age steam space above the crown-sheet is 10 inches, and the compression of the 204 inches of steam into 10 inches would give a pressure of 20.2 atmospheres or 300 lbs. per square inch momentarily added to that of 90 lbs. already existing in the boiler. The cross-section of the strain above the crown-sheet is 42 inches. Thickness of the iron $\frac{5}{16}$ of an inch, or total section of iron to be broken $\frac{5}{8}$ of an inch. Breaking weight from experiment=54.400 lbs. per sq. in.

Then $\frac{54000 \times 5}{\frac{5}{32}}$ } Breaking strain of perfectly stayed$=\frac{54000}{42}=810$ pounds per sq. in.

Deducting 20 per cent. for rivets=648 lbs. per sq. in., or, according to Fairbairn, deducting 44 per cent. for single riveted joints=454 lbs. for bursting strains.

Let us now suppose the crown-sheet and bars to have been heated to a temperature of 660° Ft., and to be reduced to 485° Ft., the loss of temperature—175° Ft. Then $175 \times 1{,}110 = 194{,}250$ heat units, or $\div 8 =$ 24,281 lbs. of water heated 1° Ft.

Sensible heat of steam at 570 lbs. = ...	485°
" " " 90 lbs. = ...	335°
Difference	150°

This added to the latent heat of steam at 570 lbs. = (777° + 150° =) 927° as the units of heat necessary to convert water at 335° Ft. into steam at 485° Ft.

Then 24,281 ÷ 927 = 26.19 lbs. of water converted. This amount of water would cover the crown-sheet to a depth of 0.228 inches, and would yield an amount of steam of atmospheric tension sufficient to occupy a space equal to a prism having the crown-sheet for its base and 387 inches in height.

When compressed into a height of 10 inches this steam would suddenly add a pressure of 38 atmospheres or 570 lbs. per square inch to the previous pressure of 90 lbs. per square inch, and would give a total pressure exceeding the 648 lbs. per square inch in the maximum of force necessary to tear the boiler apart, as derived from experimental trials of the strength of iron.

I have endeavored by experiment to fix the temperature at which iron, with such a surface as that from this boiler, will produce a spheroidal state in water flowed upon it. When the samples of iron were floating upon boiling mercury (662° Ft.) they failed to repel the water but converted it rapidly into steam.

The specific heat of iron, at high temperatures, averagiag about 0.122, and its specific gravity 7.8, we can assume that an iron plate will raise the temperature of a stratum of water in contact with one surface, and of its own thickness in depth, 1° Ft. for every degree that it loses in temperature, or that it will convert about $\frac{1}{1000}$ of that amount of water at the boiling point into steam of high tension.

The crown-sheet of the furnace of this locomotive, with its stays and girders, weighed 1,110 lbs., and had a surface of 22 square feet, this gives a mass of iron equal to an average of 50.45 lbs. per square foot, or an average thickness of 1.23 inches of iron plate.

Such a plate could therefore raise a stratum of water 1.23 inches in depth 1° Ft. for every 1° Ft. of temperature lost by the iron, or would convert a stratum of water 0.00123 inch in depth into steam.

In our second example, we supposed the temperature of the iron to have fallen from 660° Ft. to 485° Ft., a loss of 175°; this would give us $0.00123 \times 175 = 0.21525$ inch as the depth of water converted into steam, and which, under the conditions stated, would give a pressure of nearly 37 atmospheres in addition to that already existing within the boiler by the transfer of heat from the iron.

This leads to the conclusion that the substitution of a crown-sheet $\frac{5}{16}$ inch thick, stayed without girders, would require the contraction of the space between the crown-sheet and the roof of the boiler to an average of $2\frac{3}{4}$ inches, to allow of the sudden production of a pressure of steam equal to that capable of development in a boiler constructed as was the one exploded, or the effect of an equally overheated crown-sheet would be reduced to $\frac{1}{4}$ of that which would otherwise have been produced.

That such is the fact was clearly shown by the result of a recent accident to another locomotive in which the crown-sheet was simply forced down, as by a gradual increment of pressure tearing out the stay-bolt and permitting the steam and water to escape into the fire-box and extinguish the fire without further injury to the boiler or engine.

C.—Level of Water in Boilers. (How Affected.)

There are several conditions under which an engineer may be deceived as to the level of the water in the boiler of a locomotive-engine. The most important are:

1. Priming or rise of water-level.
2. Changes of grade.
3. Variations in the speed of the engine.

In all boilers the level of the water is somewhat raised whenever steam is taken off. The amount of the rise is varied by the rapidity with which steam is conveyed away: the form of the boiler and the manner in which heat is applied for the production of steam.

In boilers in which there are narrow water spaces surrounding the fire-box, and those in which heat is conveyed to the water locality, that is, the heating surfaces are small in extent as compared with the whole volume of water, and are very hot, the lift of the water is very considerable whenever an outlet for steam is opened, amounting in some instances to as much as 12 and 14 inches.

In ordinary locomotive boilers the rise upon opening the throttle or safety-valve averages about 4 inches.

The presence of oil in the boiler greatly increases the foaming. The

influence of changes of grade is rarely considered by locomotive engineers. The change from a level road to an ascending grade of 100 feet per mile would cause the water in the boiler to flow back to the fire-box end so as to raise the water-level about $1\frac{3}{4}$ inches, depressing the water-level forward by the same amount or a total variation of $3\frac{1}{2}$ inches.

If the level of the water be found at the top gauge whilst the engine is running with unvarying velocity up a grade of 100 feet per mile, and the engine be stopped upon a descending grade of 100 feet per mile, the actual level of the water over the crown-sheet of the fire-box would be $11\frac{1}{2}$ inches below the top gauge-cock.

If the first observations had indicated one gauge of water only, the actual level of the water, after the engine had been stopped on the descending grade, would be far below the level of the crown-sheet.

From observations made upon an engine by means of a glass gauge on the water column, I have found that the water-level is greatly disturbed during the running of the engine by every change of speed. Whilst at rest the water surface is level; upon starting the engine the water does not take up the motion immediately, but is crowded to the back part of the boiler, and remains so in a greater or less degree until the motion is checked, when the water at first becomes level and then crowds towards the front end of the boiler until the engine is stopped, when its surface becomes level. Running at a speed of about 25 miles an hour, first forward and then backward, the variation at the water-level was about four inches.

D.

A record has been made of the effect of injecting fresh water into boilers containing hot concentrated solutions of various salts; but as analysis of the water supplied to this engine show that they contain but a moderate percentage of salts in solution, it is unnecessary to give the results of the experiments, as the effect produced in practice would add but little to the destructive forces already fully explained, and which are of themselves more than sufficient to account for explosions under the conditions stated.

AN OBITUARY NOTICE OF CHIEF JUSTICE JOHN MEREDITH READ.

By Eli K. Price.

(*Read before the American Philosophical Society, December* 18, 1874.)

It is within the scope of our comprehensive charter to commemorate the life and character of our deceased members. To do so is to promote knowledge, and to render service to science and society. It is thus the dead shall yet speak, and through our press speak to the most intelligent of the civilized world, and to such in future times.

He whose memory we would perpetuate to-night was a most diligent student and able administrator of the science of jurisprudence; that

science without whose protection no other science could be cultivated; nor civilization, or happiness, be maintained among mankind.

John Meredith Read, LL. D., a member of this Society, died on the 29th of November, 1874. He was son of John Read, a former Senator of this State, a member of the Bar, and a long time President of the Bank of Philadelphia; and a grandson of George Read, a signer of the Declaration of Independence and the Constitution of the United States; and Chief Justice of the State of Delaware. Our fellow member was born in this city July 21, 1797, graduated at the University of Pennsylvania, A. B., in 1812; was called to the Bar in 1818. He was elected to the House of Representatives of this State in 1822 and in 1823. He was afterwards City Solicitor and member of Select Council, and in the latter capacity drew up a full and connected account of the finances of the city. Yet later he was successively District Attorney of the United States, and Attorney-General of the State of Pennsylvania. An enumeration of numerous pamphlets containing his reports and arguments may be found in the second volume of Allibone's Dictionary of Authors, under his name.

Long before his elevation to the Bench Mr. Read stood among the leaders of the Bar of Philadelphia, at a period when it was greatly distinguished; when his cotemporaries were the Sergeants, Binney, Chauncey, the Rawles, the Ingersolls, Williams, Meredith, and other eminent counsellors and advocates. His arguments can be here described but by their general characteristics. These evinced the most careful and thorough preparations, both as to facts and law, with an ample brief written by his own hand. From this he spoke with great earnestness and power, with a strong voice. His own strong conviction preceded and was potent for the convincement of court and jury. You never perceived that he spoke because he was employed to speak, but because he felt it his duty to speak; and he no doubt did generally speak according to his actual conviction.

In the celebrated trial of Hanway, in 1851, for treason, Mr. Read was engaged with Thadeus Stevens and J. J. Lewis for the defendant. His preparations for that trial were thorough, and the defence was masterly and successful. In preparation he studied the slave laws of the South, and the law of treason as held in England and the United States. Mr. Stevens afterwards said of that argument. "This speech was never fully reported; if it had been it would have settled the law of treason in the United States for a century." The alleged treason consisted in defending fugitive slaves from capture. Hanway violated the law, but did not levy war against the United States; therefore, did not commit treason.

Though Mr. Read belonged to the Democratic party, he always had a repugnance to slavery; and when the Missouri Compromise was annulled, and that party sought to extend slavery over the territories, it was of necessity that he should soon leave it for the "Free Soil" movement. In a Democratic Convention held in Pittsburgh, in 1849, he offered a resolu-

tion against the extension of slavery, which concluded in these words: "Esteeming it a violation of State Rights to carry it beyond State limits, we deny the power of any citizen to extend the area of bondage beyond its present dominion; nor do we consider it a part of the Constitution that slavery should forever travel with the advancing column of our territorial progress." From that time he became the zealous opponent of the slave power; and when the time came to form the Republican party he was prepared for the work, and from the first, and always, was a supporter of its principles and policy.

Even on the Bench political and Constitutional questions will arise which judges must decide, and will decide according to their political convictions; and this happened several times during the war of the rebellion, when it was in the power of the Courts seriously, if not disastrously, to hamper the action of the National Executive and Congress, for the suppression of the rebellion. In those cases Judge Read was one of the majority of three who uniformly sustained the acts of Congress and the measures of the Government to suppress the rebellion.

When the subject of consolidating the many corporate districts round the old Philadelphia of two square miles into one enlarged city, during the middle years of this century, was agitated, Mr. Read was an earnest advocate for that measure. Though he took no part in framing the new charter, he had prepared statistics of population and finances, which, with the influence of his name, were important to help carry the measure with the people, and the bill in the Legislature.

Mr. Read was elected a Justice of the Supreme Court of Pennsylvania in October, 1858, and commissioned for fifteen years from the first Monday of December of that year. He entered upon the discharge of his judicial duties with an earnest zeal, and performed his full share of the onerous duties of the Court, with exceptions when prostrated by ill health. His opinions are peculiarly characterized by a full history of matters having a bearing upon the cause, and the full citation of judicial authorities applicable to the case. The act of 1810, prohibiting the reading of British precedents, had been repealed in 1836; so that all the investigations and learning of the British Courts were at the service of counsel and the Court. Judge Read, who always desired the fullest light upon the subject of decision, made, while at the Bar, and expected as a Judge, a full citation of the relevant authorities by the counsel, and he carefully availed himself of all that could assist the judgment of the Court. His opinions, therefore, were full of learning, and he brought into our courts, from England and the other States, views and principles that without him would not have enriched our law. His library was extensive, and he kept it furnished with the latest publications; that is, with the most recent editions of elementary law, and the English Reports, and those of other States, as fast as they came from the press.

The opinions of Judge Read ran through forty-one volumes of the Reports; that is, from the 32d to the 73d volume, both inclusive, of our

State Reports. In the first of them we find the evidence of his ardent love of justice, in the severe reprobation of any one being removed from office without notice of the charges made against him, and an opportunity of being heard in his defence. (32 St. R. 478.) In the second of them he delivers the opinion of the Court on the will of Stephen Girard, which decides the city of two square miles to be that preferred in the admission of boys to the College, and that a fatherless child is an orphan within the intent of the will, though the mother be living. It gives the early history of Philadelphia; refers to the customs of London; with a brief biography of Girard, and then he interprets his will, with the aid of lexicons, and Biblical and legal authorities.

Judge Read was always strict in his requirements that trustees should faithfully execute their trusts, both as respects the selection of the proper objects of investment, and as to proper care in making them. (34 St. R. 100.) While he favored the creation of trusts for proper purposes, he was stern in the protection of trust property from insecurity and loss. (46 St R. 494; 41 St. R. 505; 51 St. R. 292.)

As to the power of the United States to levy troops, he held that "Every citizen is bound to serve and defend the State as far as he is capable. No person is naturally exempted from taking up arms in defence of the State; the obligation of every member of society being the same. Those alone are exempted who are incapable of handling arms, or supporting the fatigues of war. This is the reason why old men, children, and women are exempted." (45 St. R. 285.)

His opinion was potential with members of Congress to induce the passage of the act of Congress of March 3d, 1863, authorizing the President, during the rebellion, to suspend the writ of habeas corpus. A letter from Senator Sumner declared his argument conclusive, and it was effective in passing the act.

The labors of the Judge were mostly in the well trodden highways of the law, and his merit consists mainly in knowing well, and keeping to that beaten track. The charm of novelty and new discovery are seldom to reward the industry of the Judge. The merit of adherence to precedents will be easily understood by the layman who has invested the earnings of his life on the opinion of counsel, which opinion must be based on judicial decisions, if succeeding judges can declare the law to be otherwise than it had been held; for such decision pronounces the law for the past as well as for the future, and the citizen may thus lose the law that protected his title by the decision of a cause in which he was not heard. Judge Read was a faithful adherent to established precedent, and hence was an eminently safe and conservative judge.

This is not the place to enumerate the many contributions made by him from the great treasury of British and American law, to the body of the law of Pennsylvania. A notice of a few of these must suffice for an estimate of the value of the judicial services of Judge Read. The profession and the public are indebted to him for the first step made for the

security of title, under our modern acts of limitation, in holding when sitting alone, that a purchaser will be compelled in equity to take a title dependent upon the statutes of limitation for its validity. (6 Pha. R. 185.) One of these statutes removed all exceptions on account of the disability of the claimant, after thirty years' adverse possession. That decision was followed by corresponding decisions by the Supreme Court. (17 St. R. 396; 65 St. R. 55.)

When Pittsburgh City and Allegheny County made default in the payment of their bonds, Judge Read united heartily with his brethren of the Supreme Court to compel those municipalities to meet their obligations, requiring them to lay taxes for that purpose. In his opinion on one of those cases, he says, "Whatever may be said as to the individuality of acts of officers and agents *outside* of their authority is wide of the mark, when attempted to be applied to defective execution within the sphere of authority. The one may be void, but every principle of justice, as every presumption, forbids such conclusion in the other case." Those dealing with officials are not to suffer by their irregularity. "Public business could never be done under such a system. There must be faith in public servants within the scope of their authority, or public business must stop. For defective execution, the public, whose servants they are, must suffer, not innocent parties." (37 St. R. 287–8.)

Judge Read is entitled to especial praise for the part he took in saving special trusts to the jurisprudence of Pennsylvania. Since 1829 a series of decisions made by the Supreme Court had established the law giving validity to special trusts to protect the improvident, helpless, or incapable, by the interposition of trustees. In 1856 there was commenced a counter course of decisions that threatened to deprive parents and benefactors of the power of safely making provision for the unfortunate and helpless. This is a power that all considerate persons would be likely to consider an indispensable one for the welfare of civilized society; yet its existence in our law was threatened. In 1864 the Supreme Court had the opportunity of arresting the downward course of decision, in the case of Barnett's Appeal (46 St. R. 392.), and to Judge Read was assigned the duty of writing the opinion of the Court. He says: "The principal error is in laying down as the law of Pennsylvania, that a trust to receive rents and pay them to another is executed, although not an use executed by the Statute of Uses, but arising from some general principle inherent in the common law of the State. This is not supported by authority." The Judge then proceeds to review the course of decisions prior to the innovations, and restores them into authority; and, with slight modification or exception, these remain in authority down to the latest decision of the Supreme Court. The opinion concludes: "The question then is, shall the settled law of Pennsylvania, as to trusts, remain as it was understood by all our tribunals and the Bar, and had been received since the foundation of the Province to within the last eight years, or are we, without the sanction of the Legislature, entirely to uproot it, and substi-

tute a new system which has been the subject of serious criticism and constant complaint? We do not approve of such judicial legislation, and are therefore of opinion that the Auditor and the Court below erred in declaring that there was no estate vested in the trustees of the testator's will, and, so far, the decree must be reversed." That is, the Court decided that the trustee should hold the title and manage the estate, for the benefit of the beneficiaries; and must hold and protect it upon the trusts specified by the testator.

Another occasion of Judge Read's delivering the opinion of the Supreme Court had a direct interest for this Society; and is also interesting to the science of jurisprudence, though the occasion for its citation as authority may not be frequent. When the square upon which this hall stands belonged to the Commonwealth, the Legislature granted to this Society the perpetual use of this lot for the purposes of this Society, esteeming our objects to be of such public benefit as to comport with those for which the square was held by the State. Though this is a perpetual right in the Society, it was not such a title as could be aliened by the Society to others to be held on other uses, without the authority of the State. This title is, therefore, unique; is unlike any other title in the State. It is a great principle of the common law that titles shall be freely alienable, so that they shall best subserve the interests of civilized society. This is the reason of the rule of law against perpetuities, established by judges who were wisest of British statesmen. The exception allowed by this rule is limited by the duration of designated lives in being and a minority or twenty-one years thereafter. During that period titles may be limited into a succession of limited interests, or clothed with trusts for the maintenance of those deemed incompetent to manage their property for themselves. A special exception was created by the British Parliament, when the nation granted Blenheim and its princely domains to the Duke of Marlborough, to guard the country's gift from alienation by his heirs; and to that immunity it is owing that that splendid castle and domain have not been sold to pay the debts of the heirs of the great Duke. A partial exception exists in Pennsylvania, by an act of the Legislature of 1871 (P. Laws, 879), under which the descendants of the Indian Chief, Cornplanter, now hold their lands in severalty, but inalienably to any but Indians, so that white men may not defraud them, or intermix in the colony. Such a feature should be incorporated into the titles of our Western Indians, when they also shall have lands allotted to them in severalty; a step of progress that must soon be reached if they are to be preserved in existence.

The purpose of the restricted grant to this Society was to preserve the property forever for public uses; for in public and charitable uses lands may be held unalienable in perpeturity. The opinion gives a history of this society, and the following extract will show the grounds of the decision of the Supreme Court, with the friendly estimate of Judge Read, when our library was levied upon for taxes assessed upon the lot and hall:

"It is clear, then, that the Society could not charge this lot by any recognizance, mortgage, judgment, debt, obligation, or responsibility, nor could they create any lien upon it; because it could not be sold by any form of execution, and this being the case, no taxes could be a lien upon it, and no form of proceeding to recover the same could create a lien upon this lot, because it could not be sold under any such judgment. It seems stronger in the case of taxes levied under the authority of the very Government that has expressly prohibited any sale of it, except in the cases specially pointed out, and by the character of its public uses as expressly declared. The uses for which it was given are public, and can neither be affected nor destroyed by the adverse action and process of a court of law. The court below were therefore right, and their judgment must be affirmed.

"This Society numbers amongst its members many distinguished foreigners of great scientific eminence, and it corresponds with public bodies and private individuals devoted to the pursuit of science in every country in Europe; one of its latest correspondents being a Hungarian Society, whose Transactions are published in their native language. It has a most valuable library of about 27,000 volumes, of which a complete catalogue is now preparing at a very heavy expense, including a great many manuscript letters and papers of a most valuable and rare character, relating to the early history of this Province and country. A large number of the works in the library are of a scarce and rare kind, and are not to be found on this side of the Atlantic, including a complete set of the Transactions of the Royal Society of London, commencing two centuries ago. The first President of this Society was the originator of the first fire company, the first public library, the first hospital, and the first academy, now the University of Pennsylvania, a signer of the Declaration of Independence, Minister to France, one of our Ministers Plenipotentiary who signed the provisional articles and the definitive treaty of peace between the United States and Great Britain, and finally one of the framers of the Constitution of the United States.

"This was Dr. Benjamin Franklin, the patriot and the Philosopher; and I cannot but express a confident hope that the City and the State of which he was so distinguished an ornament, will never permit the hands of the tax-gatherer to diminish the fund devoted to the interests of science in every part of the world, both in peace and in war, and belonging to a Society of which he was the founder."

Judge Read, in an opinion concurring with his brethren on the bench, held the Southern Confederacy to be "an entire and complete nullity: The country and the people embraced by this unholy rebellion are simply in a state of rebellion, and are rebellious citizens, but at the same time they are enemies, and may be treated as such. They may be tried as traitors and pirates, and may, under the laws of the United States, be convicted and punished as such, and no man or nation could complain of it as an unjust or illegal act." Yet it was held that we could and should

recognize so gigantic a rebellion as belligerents, from motives of humanity, that the war might be conducted upon the principles of civilized warfare, to prevent indiscriminate slaughter, and that there might be an exchange of prisoners of war. This, he held, might be done without "recognizing the rebel leaders, or their organization, but constantly denying them to be a government *de facto* or *de jure*, or as possessing the powers to issue letters of marque and reprisal, or to fit out privateers, or armed vessels, or to make captures, or to establish prize courts which could condemn as legal prizes the vessels captured by their cruisers." (47 St. R. 180.)

An opinion of the Supreme Court, delivered by Justice Read in 1865, is interesting to science and to every one who travels by railroad. It was a suit by a widow and children against a railroad company for the loss of the life of a husband and father, by alleged negligence, under one of the modern statutes in such case. It is held that at the common law no action was maintainable against a person who caused the death of another; also that *an opinion* of the value of the life lost, by competent judges, is lawful evidence. The loss to be computed is simply that which would be compensatory to the surviving family, in the ability of the deceased to provide for his family. It is therefore held to be a proper inquiry of a witness, from his knowledge of decedent's age, habits, health, and physical condition, how long he would have been useful to his family. From liability for the company's negligence they cannot stipulate for exemption. (51 St. R. 315.) This seems a very mercantile estimate of the value of human life; yet, considering the ready sympathy of juries with the bereaved family, it is the only one that carrying companies can endure and live.

In 1866 several cases involving the validity of the legal tender act, came before our Supreme Court, and its constitutionality was sustained. Judge Read's opinion gives a history of paper money in America. (52 St. R. 71.) In 1819 the Supreme Court of the United States had decided that Congress had the power to create a bank whose bills or notes should be receivable in all payments to the United States. If Congress could do this, the logical inference was that Congress could directly create a currency. In making such issues a legal tender Congress did but what the dependent Colonies had done. The Constitution, while denying the like power to the States, gives expressly to Congress the power to coin money, to regulate the value of domestic and foreign coins in circulation, and, as a necessary implication from positive provisions, to emit bills of credit. Congress was expressly clothed with power to enact all laws necessary and proper for carrying into effect the enumerated powers; and this act was necessary to that end. "This was done at a time and under circumstances which admitted of no other means to carry those great powers into full and effective operation." It was a measure requisite to save the Government and protect the people, in the war of the rebellion; and will be a measure necessary to save and protect them in

all future great wars. Every government must be sufficient unto its own existence; otherwise it must perish.

The Supreme Court of the United States, in 1870, Justice Strong, who had concurred as one of our Supreme Court in the opinion of 1866, delivering the judgment, also decided the validity of the legal tender act. (12 Wal. 457.) That Court held that Congress, besides those specified, had express power to make laws necessary to carry into effect "all other powers vested by this Constitution in the Government of the United States;" and say, "It was certainly intended to confer upon the Government the power of self-preservation." (p. 533.) The import of all the Constitution is to be regarded in the ascertainment of the powers of the Government; and it certainly acquired the universal right of self-preservation. It may not then by self-restrictions and abnegation destroy itself, and thereby fail to fulfill the purpose intended by the American people, and extinguish the fairest hopes of mankind for republican liberty.

In 1867 Justice Read delivered the opinion of the Supreme Court of Pennsylvania, protective of our City's Water Supply, in restraining the pollution of a tributary of the Wissahickon, in which several salutary general principles were applied: No one has a right to foul a stream and make it unfit for domestic use to those below: If the upper riparian owner claims right by prescription he can only succeed for the extent of pollution which existed twenty-one years before: The prescription requires the strictest proof, because it is against common right. The opinion is learned and able. (54 St. R. 40.)

In the same year Justice Thompson and Justice Read wrote concurring opinions, and the majority of the Supreme Court refused the strong remedy of injunction to prevent the running of passenger cars on Sunday. In this case Judge Read uses the language, "We have public squares and a great public Park owned by our fellow citizens, and intended for their benefit, and that of their wives and children. Clergymen, lawyers, physicians, merchants, and even judges have six days in the week in which they may enjoy all these and other advantages, and which they may do cheaply by means of the passenger railways. The laboring man, the mechanic, the artizan, has but one day in which he can rest, can dress himself and his family in their comfortable Sunday clothes, attend church, and then take healthful exercise; but, by this injunction, his carriage—*the poor man's carriage, the passenger car*, is taken away, and is not permitted to run for his accommodation. The laboring man and his children are never allowed to see Fairmount Park, a part of his own property." (54 St. R. 451.)

In January, 1871, the opinion of the Supreme Court was delivered by Justice Read upon the act which authorized the Public Buildings to be erected on Penn Square. Holme's first plan of our City laid out a Centre Square, and one in each of the four angles of the city: the first for buildings of public character, the others to be for the like uses as the Moorfields in London. A history of the location and uses of

Moorfields is given in the opinion, and also that of Penn Square; and the Court had no difficulty in sustaining the validity of the act, as "the Legislature is simply appropriating the square and the streets to the purposes to which the square was originally dedicated." (63 St. R. 489.)

But a few more cases illustrative of the judicial character of Judge Read must suffice. One is a new application of an equitable principle, made necessary by modern legislation, enacted with purpose to favor women's rights. By statute a widow may reject her husband's will, and may elect to take her intestate share in both real and personal estate. Her doing this disturbs the plan of the will, and usually disappoints other legatees. It is just, and so decided by our Supreme Court, that the benefit intended by the will for the wife shall be sequestered to compensate those legatees whom her election has disappointed. (65 St. R. 314.) Again: one under equal obligation to make contribution, as where one co-surety has paid the whole debt, the other is held bound to refund a rateable proportion; but this rule does not hold between joint wrongdoers where one has paid the whole damage, from a policy to discourage such combination to do wrong. But this is confined to cases where the plaintiff is presumed to know that he was doing a wrongful act. Therefore, where a traveller has recovered against one or two counties, bound to maintain a county-line bridge, owing to the bridge breaking down, the county paying the whole damage may recover contribution of the other. (66 St. R., 218.)

A testator must be of sound mind to make a valid will; but if the unsoundness does not affect the general faculties, and does not reach his capacity of testamentary disposition, he may make a valid will. Physicians and unprofessional witnesses may state their opinion of the sanity or insanity of the testator, with the difference that the former are heard as experts. (68 St. R., 342.)

You may perceive from these decisions that a philosophy of practical wisdom pervades the law; and those who know it best are the most ready to assent to the boast of Lord Coke, its greatest ancient authority, when he speaks of "The law, which is the perfection of reason." In it are found the wisdom of all practical life and morals, the rules of conduct, of individuals, society, and governments, and, consequently, it contains the larger and most useful share of the philosophy of the human mind. You have not, therefore, been led into foreign fields, but into those where we should find our more familiar range. The law it is that must preserve the peace and well-being of our race. Its philosophy and progress are worthy the study of the highest intellects. As perfect as Lord Coke thought it, the law has ever since his day been improving towards a higher perfection; and generally the progress has been made in manner to preserve intact the obligation of contracts and the vested rights of property.

When Chief Justice Thompson's term of office expired in December, 1872, Judge Read as senior judge became Chief Justice. This highest judicial office of our State Chief Justice Read held for one year, when his

term expired. For some years his health had been failing, and at times he was unable to take his seat on the Bench, which fact increased the labors of his brethren. At the Bar meeting held for Judge Thompson, after his sudden death while speaking in Court, Judge Read made acknowledgement of the kindness of his brethren. He said: "I have known my deceased friend intimately for fifteen years, for fourteen years of which we were members of the same Court. He was a most kind and considerate associate, and I am personally deeply indebted to him for his thoughtfulness and attention to myself when ill-health called for the indulgence of my brethren. He was a good man, an honest and upright man, an admirable Judge, and a learned lawyer, with great good sense. I was warmly attached to him, and I deplore his loss. I believe every word of the resolutions offered by Judge Porter to be true and eminently just, and a proper tribute to the virtues, talents and great ability of our deceased friend."

Within a day or two after his retirement from office, the late Chief Justice Read called upon the writer of this notice, who had been writing against the new Constitution, and said, "I am again a free citizen, and can speak my mind freely. I also am opposed to this new Constitution, and have an objection to it you have not taken: it is destructive to the secrecy of the ballot." His article appeared December 8th, 1873. The numbering of the voted ticket with the same number set against the name of the voter in the list of voters as required discloses how he voted. The late Chief Justice says, "The freedom of elections depends entirely upon *the ballot* and its *inviolable secrecy*, so that no man shall know how any elector has voted. This secrecy enables all men, in all the walks of society, to deposit their ballots in perfect security that the knowledge of their vote is strictly confined to their own breasts." The officers of election in the State he stated to be 12,795, who know on the night of the has election how every man in the Commonwealth voted. He also takes objection to the great invasion made upon the elector's franchise when there are two candidates, which prevents him from voting *against any* candidate, and makes the voting for the other a useless form. This able article, the last written by him we commemorate, shows his undying love of liberty and justice; his sacred regard for the equal rights of the citizen; his anxiety to protect the humble and poor from dictation and oppression; and his desire to preserve the value of the elective franchise to the citizens.

I would here give the testimony of his associate on the Supreme Bench, Judge Williams, at the Pittsburg Bar meeting, on receiving the news of the death of the late Chief Justice: "He possessed talents and learning of a very high order, and his personal and official influence was very great. He was a gentleman in every sense of the word; a gentleman of the old school, of the very highest sense of honor, of great dignity of character, and in social intercourse kind, affable and courteous." "He had an accurate knowledge of American History, especially of the times

in which he lived, and was familiar with the personal characteristics and history of the men who have been prominent in our State for the last sixty or seventy years, and it was this accurate knowledge which made his conversation so charming and instructive. He was a true friend; strong and unswerving in his attachments; ready to make any sacrifice for his friends, and when in trouble was untiring in his efforts to serve them. He was a man of the strictest integrity, and despised everything that was low and vile. With him the equity and justice of the case *was the law of the case.*" "He was a man of chivalrous courage, persistent purpose and inflexible will. He did not know what fear is." "It is the will power which gives executive ability and persistency of purpose, and enables one to achieve great results. Judge Read had this power to a remarkable degree." Such testimony from such a source is very strong, for judges sitting together for many years, discussing and deciding the many diversified and important cases which come before them, at the same time settling the law of the State, must make them thorough judges of the attainments and qualifications, and of the temper, disposition and self-control of their associates. There is to be added to the above delineation of personal traits, the fact that the characteristic courage and determinate will, were not exercised without the careful research and thought which produced certain belief of rightful action.

The characteristics of Judge Read's judgments were a plain and terse simplicity, without attempt at ornament. It is no exception to this to admit that many of his opinions are long. As a general rule they are short; and when not so, their length is owing to a full history, or statement of facts, and an ample citation of authorities; but all are given in brief language. His practice was to state the facts fully and clearly, and then without process of argument, to apply all the law, British and American, applicable to the facts; and it is at once seen that these warrant the conclusion announced. So conservative was he, that in his hands the law, as well-read lawyers are trained to understand it, was felt to be safe from innovation, while he fearlessly attacked recent innovations, and sought, with large success to restore our jurisprudence to its ancient foundations, except as these had been changed by statute, or the constitutions; methods of progress which could have no retrospective operation to divest vested rights.

Judge Read seemed to have selected no especial branch of the law in which he became more authoritative than in others. His general preparation in all was full; yet he never argued or decided a cause without a special and full study of the case, applying all the proper authorities; hence he was always accurate, and his opinions are mines of erudition for the student, lawyer and judge. In whatever branch of the law the question arose he met and disposed of it with the like able grasp and learning. He was equally familiar with Civil and Criminal law and their practice; with International and Municipal law; with Law and Equity; with the Titles, Limitations and Descents of Real and Personal Estates;

with Wills, Legacies and Intestacies ; with the Constitutions, Charters and Statutes of the United States, the State, and of our Cities. With the Laws, Ordinances and Usages of Philadelphia he was especially familiar. His love for his native city was intense, and he was ever ready to devote his time and talents to her service. His zeal continued to the last ; and he was earnest in his efforts that this should be the place of the Centennial Celebration, and that it should be a great success. His patriotism never grew cold or suffered loss from the chill of age ; but he was always young, progressive and ardent for the progress and improvement of the City. The Park, Public Buildings, and wide well-paved streets, and the water supply were objects of his lively sympathy.

The State and United States, their welfare and prosperity, were also very near to his sympathies, and he was ever alive to all that concerned their well-being and safety. This is shown in all the acts of his life, both as citizen and judge. That he lived and labored in the law as he did, and was the able and patriotic citizen that he was, make the name of Chief Justice Read an honor to his family, his City, his State, and Country, and by them all his memory will be held in respect and honor through future time.

The late Chief Justice Read left to survive him, a widow, and his only heir, John Meredith Read, who ably represented our Country, as Consul General to France, and resided in Paris during her fearful investment by the German armies, in 1870 ; and who now again represents our Nation as Minister to Greece.

Chief Justice Read lived and died in the Christian faith ; and was ever an opponent of those false philosophies of France, Germany and Great Britain, and more sparcely of our own Country, which seek to undermine the Christian religion ; that religion which gives to life its greatest consolations, and enables man to triumph over the fears of death ; that religion whose immortal faith, alone, gives adequate meaning to the Universe.

ON THE ALLEGED PARALLELISM OF COAL BEDS.

By Jno. J. Stevenson.

(*Read before the American Philosophical Society, Dec.* 18, 1874.)

That coal seams are approximately parallel, is a common belief among persons residing in the coal fields of our country. The more observing of our coal operatives, however, long ago discovered that the assertion of parallelism is a fallacy, and that the interval between any two given beds of coal is liable to vary many feet in thickness within comparatively short distances. So general is this variation that it amounts to a positive law. Until this was accepted as a fact, to the utter exclusion of any notion of parallelism, the coals of southwestern Pennsylvania remained a worse than Chinese puzzle to Geologists, and

every attempt to tabulate them was a failure. For many years the reports of all observers led us to accept the divergence or convergence of coal seams as part of the necessary arrangement of things, a phenomenon quite as ordinary as the occurrence of sandstone or shale in the intervals.

Quite recently, Prof. E. B. Andrews, an assistant on the Ohio Survey, has re-asserted the parallelism of coal-beds, and admits of such exceptions only, as result from the greater or less compressibility of the materials occupying the intervals. He concedes, it is true, that when large areas of any coal field are examined, it may be found that some portions have had a more rapid subsidence than the rest; but he maintains that as a rule the subsidence was so regular that two seams are found to present an almost perfect parallelism. He doubts whether it is possible for a seam to separate into two or more parts, or if separated, for the parts to diverge indefinitely, that is to say, I suppose, for several miles horizontally or to any great extent vertically.

This is no matter of merely theoretical interest. Involving, as it does, not merely the whole question respecting the deposition of coal seams and the intervening rocks, but also, as a consequence, the identification or tracing of the beds over extensive areas, its exact determination is equally important to the economic investigator and to the purely scientific student. It is true, that the question has been a settled one for many years, but long acceptance of a doctrine does not prove its truth. It has been disputed by a Geologist of standing, whose statements deserve and receive consideration. There is need then, that the matter be presented in such a manner as to leave no doubt in the mind of any that the idea of parallelism over even limited areas is utterly fallacious except for rare localities. In geology an erroneous theory is of necessity a pernicious theory.

Coal seams do divide. That is to say, the numerous partings in a coal bed are liable so to thicken as to become distinct strata of shale or sandstone, and in many cases they do so thicken. In his memoir upon the South Staffordshire Coal Field, Prof. Jukes gives an illustration, especially interesting because of the ease with which the bifurcation of the various seams is proved. The coals begin their separation in the southern portion of the field and the divergence continues northward, the coals never coming together again within the area embraced in the memoir. In Plate 1, Prof. Jukes compares two vertical sections, one taken in the south-central portion of the field, and the other in the north-central portion, the distance between them being about five miles. In the first section, which represents a vertical thickness of 350 feet, there are seven beds of coal, each made up of several distinct layers separated by their partings. In the second section, whose thickness is 850 feet, there are eighteen beds of coal, some simple, but most of them compound. The character of the coal from the several seams in the second section shows at once the relation to the beds of the first section.

To give all the details leading to the conclusion offered by Prof. Jukes, would be impossible here. I therefore present only a few sections, showing the variations of a single bed within a limited area, sections obtained in such proximity to each other, that no possible doubt remains respecting the identity of the coals :

	1	2	3	4	5	6
Flying-reed Coal,.....	4′	4′	4′8″	4′4″	2′6″	3′
Interval, ...	0	10′6″	45′9″	55′4″	118′	128′
Thick Coal,.....	25′4″	25′4″	22′6″	24′3″	24′	22′8″

Further sections* show that the *Thick Coal* finally breaks up into nine beds, the whole occupying, with the intervening rocks, a vertical space of 390 feet. The sections given above show that, within a distance of less than one mile, the interval between the two benches of the seam increases from zero or a very thin parting to 128 feet. The extent of area forbids the supposition that this occurred in a petty lagoon. It is, as I hope to show hereafter, in full accordance with the law of coal deposition in our own country.

Other instances might be cited from Great Britain. Thus Mr. Greenough† states that near Ashby de la Zouche, the *bend*, separating the second and third seam of coal, is in the easternmost coal-pits, thirty-three yards thick ; in the next toward the west, twenty-five ; in the most western, only fourteen ; and that in the Budworth Collieries, half a mile further toward the west, it vanishes entirely, the two seams running together. Another instance is mentioned by Capt. Portlock in his report on Londonderry, etc., pp. 600-601.

In our own country, such marked illustrations though rare, are by no means wanting. The bifurcation of the Mammoth Coal Seam is a well ascertained fact and susceptible of absolute proof. At Mahanoy City, Pennsylvania, one of the most important beds divides, and its branches can be traced for a considerable distance, rapidly diverging. On the Great Kanawha River, in West Virginia, as I have shown‡ the celebrated seam worked at Coalburg, shows this tendency to divide. At the east end of the property of the company these partings are thin, rarely exceeding three inches Followed westward, they increase, until at the western boundary of the property the lower one is two feet thick. About ten miles further down the river, three thin coals are found occupying the horizon of this bed. In all probability, they are simply the subordinate coals, separated by the greatly thickened partings. Cases of distinct division of coals, attended by marked divergence of the benches, must

* For the sections given above, see *The South Staffordshire Coal Field*, by J. Beete Jukes. 2d Edition, 1859, pp. 87 and 38.

† *A Critical Examination of the First Principles on Geology*, by G. B. Greenough, President G. S., &c., 1819, p. 22.

‡ Annals of Lyceum Nat. Hist., Vol. X, p. 276.

remain rare in our coal fields until the workings become more extensive and in closer vicinity than now. At present, it is possible only to show the marked changes in the intervals between our coal beds. In doing this, I shall draw all illustrations from the northern portion of the Great Bituminous Trough, which includes Western Pennsylvania.

Lower Coal Croup.—The total thickness of this group is subject to great variations. In Pennsylvania it is from 270 to 650 feet; in West Virginia from 200 at the Pennsylvania line to nearly 700 in Randolph County, and nearly 900 on the Great Kanawha, in Ohio from to . In each case the Mahoning Sandstone has been omitted. For detailed examination, I choose the two coals known as the Upper Freeport and Kittanning, in Pennsylvania, and as Nos. VI and IV in Ohio.

Along Yellow Creek, in Ohio, the varying interval between these two coals is finely shown in a continuous exposure from the Ohio River to Irondale, a distance of seven miles. The coals are known locally as the "Big" and "Strip" veins, and between them occurs No. V, locally known as the "Roger." I give only four sections for comparison:

	1	2	3	4
Coal VI	7′	3′7″	5′6″	?
Interval Rocks	16′	60′	60′	100
Coal V	3′	?	2′6″	?
Interval Rocks	60′	52′	65′	60
Coal IV	2′6″	?	2′6″	?

These show a variation from 80′ to 160′ within five miles; the most marked change being in the interval between V and VI.

In Guernsey and Muskingum Counties, Ohio, a much more interesting series of changes occur along Wills Creek and the Muskingum River. This line of section is an important one, as the coals can be traced almost without break. *Coal IV* is accompanied by its Gray (fossiliferous) Limestone, and VI is everywhere seen in the hills. Beginning on Wills Creek, in Guernsey County, about seven miles north from the Central Ohio Railroad, we find near the Salt Works, the two beds 8 feet apart. Somewhat more than a mile further down the Creek, IV is mined by shaft and is 28 feet below VI. Near Liberty, the interval is 40′; at Bridgeville, 105 feet. Still following the Creek and crossing into Muskingum County, we find the interval at Johnson's Mills, 40 feet; at Frew's Mills, 90 feet; at the Salt Works near the Muskingum River, about the same; near Dresden, about 100 feet, and further down the river 110 feet. The line of least interval seems to run northwestwardly through Guernsey County, from the starting point to a little east from Johnson's Mills, the beds diverging on each side of this line. The structure in a cross section is somewhat as appears in this figure, the upper line representing VI, and the lower IV.

At some distance further, northeastward, a similar relation exists between the coals. Across the intervening space VI can be traced quite

readily, but the exposures of IV are far from being continuous, and for miles it does not reach the surface. It is impossible, therefore, to demonstrate the structure, which seems to be as follows :

What the complete structure of the western portion in the first figure may have been cannot be determined, as erosion has removed all the material beyond the Muskingum River. The direct union of the two beds has not been seen, nor is it likely to be seen, since at all localities where the beds approximate they have a heavy cover.

Crossing into Pennsylvania, we take the same beds and carry the section down to the Ferriferous Limestone. The following sections are taken from Rogers' Report *

Upper Freeport C.	3′	3′	—	5′8″	—	—
Interval Rocks	35′	84′		20′	50′	73′
Lower Freeport C.	4′	3′	117′	5′	4′6″	1′6″
Interval Rocks	104′	55′		84′	130′	28′6″
Kittanning C.	3′	3′	3′9″	3′	2′6″	2′
Interval Rocks	25′	30′	33′6″	20′	55′	30′
Ferriferous Limestone	13′	12′	6′6″	8′	6′	8′

In these six sections we find the interval between the two beds varying thus : 184, 143, 142, 117, 109, and 103 feet, while the interval between the Kittaning and the Limestone varies from 55 to 20 feet.

The accessible records of observations in West Virginia are few, but some of them are of interest. In a report upon Property belonging to the Pridevale Iron Company, and situated a few miles above the junction of Cheat and Monongahela Rivers, Prof. W. B. Rogers gives the interval between Upper Freeport and Kittanning, as 160 feet, and between the Kittanning and the Ferriferous Limestone as 50 feet. On Decker's Creek, barely five miles away, I find only 26 feet between the Freeport Coal and the Limestone. The whole group is about 400 feet thick on Cheat river, and only 200 on Decker's Creek. This notable variation occurs chiefly between the upper Freeport Coal and the Limestone, as the section below the latter is substantially the same as both localities.

Going southward, we find the thickness of the whole group rapidly increasing beyond the Baltimore and Ohio Railroad, the Upper Freeport Coal still retaining its proper place under the Mahoning Sandstone, and readily traceable to Randolph County, beyond which I have not followed it. Near the State line at the north, the thickness of the group is 200 feet, in Randolph County it is not far from 700 feet. Whether or not the coal resting on the conglomerate in Randolph County is the same with that resting on the same conglomerate on Decker's Creek, is quite immaterial. It is quite certain that the interval between the conglomerate and the Upper Freeport Coal has increased from 200′ on Decker's Creek, to nearly 700 feet on the Beverly road in Randolph County.

The Upper Freeport Coal itself shows a marked tendency to break up

* Geology of Pennsylvania, Vol. II, Chaps. 18, 19, 20 and 22.

and in Upshur and Randolph Counties it does divide. Its partings thicken up and from mere flimsy plates become layers of shale several feet thick, so that the coal usually only three or four feet thick further north, is gradually converted into a mass of shale and coal upwards of twenty feet thick, which at one locality includes a thin layer of sandstone.

Lower Barren Group.—So interesting is this group in itself, and so irregular are its rocks, that it deserves consideration only because it occupies the interval between the Upper Freeport and Pittsburgh seams, two beds, which seem to be the most persistent of all found in the Coal Measures. It is separated into two divisions by a well marked stratum which in Ohio is known as the *Crinoidal Limestone*, and in Pennsylvania as the *Fossiliferous Limestone*. This I have traced from the Muskingum River round through Pennsylvania into West Virginia, where, like nearly all the Coal Measures Limestones, it disappears in the vicinity of the Baltimore and Ohio Railroad, south from Grafton. At the western exposure of the *Pittsburgh* in Ohio, this limestone is 140 feet below it. Northeastward the interval becomes successively 140, 160, 175, 190, 200, and near Steubenville and along the Ohio River 225 feet. In Pennsylvania on the Monongahela River, it is 320, and near Morgantown, West Virginia, 270. In like manner we find a varying interval between it and the Upper Freeport. At the most western exposure of the limestone this interval is 225, further east 280, at its northerly exposure 260, and at Steubenville, on the Ohio, 280 feet. At Morgantown it is 172 feet.

The total interval between the Pittsburgh and Upper Freeport, varies in thickness in Ohio, from 420 feet at the west, to 505 at Steubenville, the increase being regular toward the east. In Pennsylvania it is 200 feet, at Ligonier, 220 at Elk Lick, and on the Monongahela River from 450 to nearly 600 feet. In West Virginia, along the Monongahela and Tygarts Valley River, it varies not much from 420 feet.

Upper Coal Group.—The following table shows the synonyms of the coals of this group.

Ohio.	*Pennsylvania.*	*West Virginia.*
XIII.	Top at Waynesburg.	Not identified.
XII.	Second Waynesburg.	Brownsville.
XI.	Waynesburg.	Waynesburg.
X.	Uniontown??	Absent.
IX.	Absent.	Absent.
VIII*c*.	Absent.	Absent.
VIII*b*.	Sewickley.	Sewickly.
VIII*a*.	Redstone.	Redstone.
VIII.	Pittsburgh.	Pittsburgh.

In this group the wedge shape of the strata is more distinctly shown than in either of the lower groups, partly because of the persistence of the coal seams and partly because of the long continuous sections which can be obtained over a great extent of country. In it too, there is a

nearer approximation locally to parallelism, while at the same time, the parallelism is apparent rather than real, as the beds converge on each side of the trough. So gradual is this convergence, however, that for all practical purposes most of the beds might be regarded as parallel for short distances.

If we ascend the Central Ohio Railroad from the river to the summit, twenty-two miles west, or better yet, ascend Wheeling Hill, on the National Road, four miles from the river, we count nine well-marked beds of coal, beginning with VIII. If we descend westwardly from the railroad summit or from the National Road on the west side of the Wheeling Creek divide, we find only six beds to and including VIII, the topmost bed in each case being XIII. Let us compare the two sections.

	1	2
1. Sandstone, &c.	50′	50′
2. XIII	1′	1′
3. Shale and Sandstone	70′	70′
4. XII	1′6″	1′3″
5. Sandstone	40′	30′
6. XI	2′6″	2′
7. Sandstone, etc.	98′	100′
8. X	3′	4′+
9. Sandstone	35′–49′	40′
10. IX	2′6″	2′6″
11. Limestone and Calc. Shale	70′	70′
12. VIII*c*	4′	0
13. Sandstone	0–35′	0
14. VIII*b*	0 –6″	0
15. Limestone	20′–30′	0
16. VIII*a*	1′–6″	0
17. Limestone	12′–35′	0
18. Shale	5′–10′	4′
19. VIII	6′	5′
20. Clay and Limestone	10′	8′
21. Sandstone and Limestone	90′	96′
22. Shales, etc.		46′
23. Crinoidal Limestone		4′

The first section is that obtained on the railroad east from the summit. The second, to No. 21 inclusive, was obtained by descending from the summit across the National Road to Stillwater Creek. Nos. 22 and 23 were obtained on the railroad. This section differs from that obtained on the railroad west from the summit, only in Nos. 9 and 11, which are there 60 and 45 feet respectively, the latter being principally sandstone.*

Respecting the identity of No. 19, in both sections there is no dispute. It is beyond all doubt coal VIII, (Pittsburg). Aside from internal evidence furnished by the seam itself, there is abundant stratigraphical proof of identity. I have traced the bed, with the Crinoidal Limestone

* See Annals Lyceum Nat. Hist., Vol. X, p. 232, where I have described the action of the current causing this alteration,

below, all the way round its western and northern out-crop, from the Central Ohio Railroad to Steubenville, on the Ohio River, and thence down the river to Belleair, the initial point of the first section, where it proved to be the No. 19 of that section. My identification of No. 8, of the second section with No. 8 of the first has been called in question by Prof. Andrews,* who regards the former as equivalent to No. 12 of the Section I. No. 8, of Section II, is known as the Upper Barnesville Coal, and No. 12, of Section I, is the Glenco Coal. As I take it, *Coal X* at Glenco, is one hundred and ten feet above VIII*c* (Glenco), while at Barnesville it is one hundred and five feet above VIII (Pittsburg). There should be no dispute respecting this matter. It is not so complex as to require much skill for its determination. At Glenco, on the Central Ohio Railroad, nine miles west from Belleair, the coals are shown in the hill as in the section on the margin, and hold the same relations as in Section I. VIII*c* disappears under the railroad about two miles west, and IX at about seven. X and XI remain above the railroad to Belmont, 20 miles from Belleair, where the road rises above X. In the meantime XII is caught by the hills near the railroad. We are now seven miles from Barnesville and the railroad summit intervenes. Ascending to the summit and descending thence to Barnesville, we obtain the following sections.

Coal XI	—
Interval	100′
Coal X	—
Interval	40′
Coal IX	—
Interval	70′
Coal VIII*c*	—

1. Shales and Sandstones	in the Summit cut.	50′	
2. Coal XIII,		1′	
3. Shale and Sandstone		70′	70′
4. Coal XII		1′	1′3″
5. Sandstone and some Shale		40′	30′
6. Coal XI		2′6″	3′+
7. Sandstone, etc.		98′	100′
8. Coal X		3′	4 +

No. 8 in the second section is the upper coal at Barnesville, and it certainly is the same with No. 8, in the first, which is the one marked X at Glenco, where it clearly lies 110 feet above VIII*c*, the Glenco coal. It is evident then, since X is 110 feet above VIII*c* at Glenco, and 105 feet above VIII at Barnesville, that somewhere between these two points, the strata below No. 11 of Section I, to No. 17 inclusive, of the same section, have disappeared, bringing X about 90 feet nearer to VIII than it is at the river.

But this is not the full extent of this interesting alteration of relations. If, starting from the railroad, we go through Belmont and Jefferson

* See Prof. Andrews' rejoinder to Prof. Newberry, Amer. Journ. Sci., July, 1874.

Counties to the extreme northern exposure of the Pittsburg coal, we obtain a beautiful series of sections fully illustrating the wedge-shape of nearly every stratum between coals VIII and X. In this series *Coal IX* does not appear, as it thins out eastwardly and does not reach the line of section. It is present, however, in the sections, taken four miles west from this line. The localities of the sections are as follows:

1. C. O. R. R. 2. Crossing of Little Short Creek by Wheeling Plank Road. 3. Near Mt. Pleasant. 4. Between Short Creek and Smithfield. 5. Between Smithfield and Little McIntyre Creek. 6. Near Smithfield Station on P. C. & St. L. R. R. 7. Near Knoxville. Of these, the first two are in Belmont County, the rest in Jefferson County.

	I.	II.	III.	IV.	V.	VI.	VI.
1. Coal X	3′	—*	—	—	2½	2½	2½
2. Sandstone	40′	50′	—	—	60′	60′	30′
3. Coal IX	0	0	0	0	0	0	0
4. Limestone and Shale	70′	64′	43′	45′	6′	0	0
5. VIII*c*	4′	1½′	1′	½′	1′	0	0
6. Sandstone	25	20′	18′	20′	8′	0	0
7. VIII*b*	½′	0	0	0	0	0	0
8. Limestone	30′	15′	15′	8′	0	0	0
9. VIII*a*	1′	1′	⅔′	8″	½″	0	0
10. Limestone and Shale	25′	30′	1½	10′	6′	0	0
11. VIII	7′	5′	5′6″	4′9″	4½	5	4′

The Knoxville section, by Mr. H. Newton, is of further interest in that it shows Coal XI to be only 78 feet above X, whereas, in Belmont County this interval is from 95 to 105 feet. This series shows that the interval between VIII and X, which at the railroad is almost 200 feet, is reduced to only 30 feet at Knoxville, and that the reduction is comparatively gradual, the distance being say thirty miles.

Passing into Pennsylvania I select four sections† from a mass which are equally illustrative, and arrange them, beginning with the most western and going eastward. I take only those showing the relations of the Pittsburg to the Redstone and Sewickly, as the sections containing the higher coals are for the most part imperfect in the lower portion.

1. Interval Rocks	121′+	150′+	30′+	50′
2. Sewickly Coal	6′?	4′	3′	—
3. Interval Rocks	47′	30′	23′	
4. Redstone Coal	—	1½	3′	0 } 40′
5. Interval Rocks	50′	35′	20′	
6. Pittsburg Coal	10½	10′	9′	9′

These seem to show a diminution in the thickness of the intervening rocks toward the east. In connection with the fourth section it may be

* In the Sections, a dash signifies that the exposure is such as not to admit of accurate measurement.

† Geology of Penn., Vol. II, pp. 630, 625, 661, and 651.

well to refer to one given on p. 640, lying much further toward the west. In the latter the interval between the Pittsburg and Uniontown coals is said to be 245 feet, while in the former coal is only about 50 feet above the Sewickly and consequently but 90 feet above the Pittsburg.

In West Virginia the conditions are somewhat peculiar. In the narrow Panhandle at the north, IX and X of the Ohio section are absent. They thin out before crossing the Ohio river, VIIIc. is seen on Wheeling Creek, W. Va., but does not reappear on the east side of the trough. Otherwise the Panhandle section offers little of interest and shows no material variation near Wheeling from that obtained just west from Belleair.

In Monongahela Co., near the State line, we find on the east side of the Monongahela R. the following section: Sewickly Coal, 1 ft.; interval, 40 ft.; Redstone Coal, 4 ft.; interval, 60 ft.; Pittsburg Coal, 6 to 8 feet. On the opposite side of the river, and barely three miles away, the section is Sewickly Coal, 5 ft; interval, 45 ft.; Redstone Coal, 4 ft.; interval, 14 ft.; Pittsburg Coal, lower member, 10 ft. This change results from the disappearance of the heavy sandstone overlying the Pittsburg on the east side of the river.

The limestones of this group disappear somewhat abruptly southward, and give place to shales and sandstones, so that satisfactory sections are by no means frequent. I give for comparison the average sections for Monongahela, Marion Harrison and Upshur Counties:

1. Waynesburg Coal	6′ -9′	3′	5′	Not caught by hills.
2. Interval Rocks	183′-207′		123′	
3 Sewickly Coal	1′ -6′	240′	3″	
4. Interval Rocks	40′ -49′		41′	20′
5. Redstone Coal	4′ -5′	2′ -3′	2′ -4′	1′ - 2′
6. Interval Rocks	14′ -60′	70′-80′	20′-25′	40′ -60′
7. Pittsburg Coal	6′ -14′	8′ -9′	6′ -9′	3′ 9″-4′

I feel much hesitation in identifying the Redstone Coal in the last section, and think it much more likely to prove the Sewickly. The difference between the Marion and Harrison sections is very marked, the interval between the Pittsburg and Waynesburg being in one case 320′ and in the other, at most, 190′.

Conclusions.—After a careful study of the barren and upper coal groups throughout the northern portion of the great bituminous trough, I am convinced that as a whole the subsidence was regular, approaching uniformity, but that locally there were bulgings or other irregularities, such as could not fail to accompany any operations so extensive. The lack of parallelism results from the conditions of deposition, which rendered parallelism impossible. The two groups referred to were deposited in a great trough whose eastern boundary was the Alleghany Mountains; the western, the Cincinnati axis.* They diminish quite regularly in thickness, east and west, from a central area between the Ohio and the Monongahela

* The substance of this portion of the paper was published March 4, 1873, in Annals Lyc. Nat. Hist., Vol. X. pp. 247, *et seq.*

rivers. We may compare each group to an enormous bowl, somewhat elongate and with flattened base.

At the beginning of the upper coal era this trough was a great arm of the sea, closely land locked and communicating with the ocean at the southwest by a comparatively narrow outlet. On the east and southeast sides, rivers brought in their loads of detritus from the highlands to be spread over the bottom, which gradually declined toward the west and northwest. On the opposite shores few streams flowed out, and such as came were sluggish, bearing no coarse material. The place of quiet, pure water is marked by deposit of limestone in the north, while a similar mass, traceable through Ohio southwestwardly, marks the direction of the outlet. The low shore of the southeast is marked by the shallow water detrital deposits and the utter absence of limestones in West Virginia, south from the N. W. Branch of the Baltimore and Ohio Railroad.

The wedge-shape of the rocks intervening between the coals of this group has been shown both in Pennsylvania and Ohio, east and west, as well as in West Virginia, where the tapering is southeastward toward that edge of the trough. The structure of the trough may be illustrated as follows :

Let a basin with gently sloping sides be lined with some black substance ; then filled with some material which will become hard, in which a similar black substance is arranged in layers, some of them covering the whole surface, and others extending only part of the way from the border toward the middle. Now break away the bowl, remove the black exterior to near the base, at the same time cutting off portions of the hardened mass around the border above, so as to give the whole an irregular surface. Here we have a rude representation of the upper coal group, perhaps as good as any that can be made on a small scale. If this mass be divided vertically in two, the face of each piece will rudely resemble a vertical section across the group from Harrison Co., Ohio, to the eastern portion near the Pennsylvania and West Virginia line.

In Ohio, VIII*a*, VIII*b*, VIII*c* and IX are traced directly to where they have disappeared, while X and XI have been found successively approaching VIII. In Pennsylvania similar conditions exist, but the extensive erosion along the Alleghany slopes prevents us giving so full a presentation as that from Ohio. In each case we find the underlying Pittsburg reaching farther east and west than the immediately overlying beds, and continually approaching the higher ones, until, on both sides of the trough, farther study is cut off by the completeness of erosion.

I am, therefore, compelled to believe that *all the coals of the upper coal group are off-shoots from one continuous marsh, which existed from the beginning of the era to its close, and which in its full extent is now known as the Pittsburg Coal Seam.* During the whole time of formation of the upper coal group the general condition was that of regular subsidence interrupted by longer or shorter intervals of repose. During the time of subsidence the marsh advanced up the sides of the trough, as new

land was continually becoming fitted for its support. During repose, deltas were formed in the bay, and the marsh pushed outward on the newly-formed land. If the period of repose were long enough to permit the bay to be filled up, the marsh would cross to the other side if begun on only one, or, if pushing out from all sides, it would reach the centre. The Pittsburg, Redstone, Sewickly and Waynesburg originated at the east, for there they attain their greatest thickness, while westward they diminish. VIII*c*. IX and X of the Ohio section are thickest westward and then eastward, the first barely crossing the Ohio river; the others disappearing before they reach it.

It may be objected that a marsh requires an almost level plain for its existence. Nothing could be more erroneous than such a supposition, for all necessary conditions may exist on a hill-side with not too steep a slope. In Colorado, I found on Arkansas Pass, near the head of the Arkansas river, an immense morass covering the whole surface between the cañon walls, a distance of more than one-fourth of a mile. It reaches for several miles down the cañon, whose floor has a fall of nearly two degrees. This is no petty swamp. To all intents and purposes it is a bottomless morass, almost impassable to mounted stock.

There is every reason to suppose that previous to the upper coal epoch, the conditions were by no means so regular throughout the basin. It is highly probable that just before the beginning of that epoch, the trough was narrowed and the eastern border, at least, much raised. Otherwise it would be difficult to explain why it is that the Pittsburg Coal does not distinctly overlap the lower Barren group. At times during the lower coal epoch the folding process must have been carried on quite energetically, much more so than during the epoch of the upper coals. In the latter there are found no subordinate folds such as are exhibited in the former; such, for example, as occurred previous to the formation of the Kittanning so as to produce the secondary troughs in which that coal lies causing so great variations in the thickness of the interval between it and the Upper Freeport. It seems quite possible, judging from some observations in Ohio, that similar subordinate foldings may have taken place previous to the formation of *Coal III*, the next below the Kittanning.

In view of the facts given in this paper, I feel justified in extending my statement that the Indiana and Appalachian coal-fields were not connected during the lower barren and upper coal epochs, by asserting that there is no reason to suppose that they were ever united north from Kentucky. Whether or not they were united farther toward the south must be determined by others.

Thus far no reference has been made to the trough or basin lying east from the Alleghany Mountains and holding the Barren and the Upper Coal Group. The terrific erosion which this region has suffered, only fragmentary areas of coal remaining, renders the collection of details a work of great difficulty, and few observations exist, which bear upon the question under discussion. This basin and the Great Bituminous Trough

seem to have been branches of one great basin during the Upper Coal epoch. They were separated by a tongue of land tapering southwardly and terminating in West Virginia, not far from the Maryland line. The eastern basin rapidly lost its width, and near the union was quite narrow. The relation between the two basins, as I understand it, is rudely represented in the accompanying figure, in which A, is the western, and B, the eastern, which latter now contains the fragmentary areas of semi-bituminous and anthracite coal.

Whether or not this division of the coal-field existed from the beginning of the period, I am unable to conjecture, as my material respecting the Lower Coal Group is not sufficient. But that it had occurred before the formation of the Barren Group admits of no doubt, as that group has a well-defined saucer-shape in the Great Trough, and thickens eastwardly from the dividing area. In like manner the Upper Coal Group thickens east and west from the same region, the Pittsburg, Redstone and Sewickly Coals being as well marked in the eastern basin as in the western.

The eastern basin, as might have been expected, shows little limestone amid its strata. Surrounded on all sides by highlands, it was fed by numerous streams, which brought down sufficient detritus to render its waters turbid throughout. Its mouth was obliterated topographically by the final convulsions of the Appalachium Revolution, so that its precise position is to be ascertained only by close exploration.

The common basin, below the junction of these branches, was broad and never completely filled with detritus so as to permit the marshes to cross it; certainly at no time after the formation of the Pittsburg in that region. This bed cannot be traced across the basin, owing to the fact that it is deeply concealed in the centre, but the Waynesburg and Brownsville thin out rapidly toward the west, and in West Virginia, have almost disappeared before reaching the disturbed region known as the "Oil-break." Limestones are almost unknown, and for four hundred feet on top, the rocks are entirely sandstone and shale, all the limestones and coals belonging to that horizon being absent.

ON EXFOLIATION OF ROCKS NEAR GETTYSBURG.

By P. Frazer, Jr.

(*Read before the American Philosophical Society, Dec. 4th*, 1874.)

During an examination which I made of the Syenite boulders which compose that part of the battle-field of Gettysburg, called the "Devil's Den," (a collection of great blocks of this rock piled one on another in the wildest confusion and lying about ½ mile west of "Granite Spur" or Little Round Top, the ravine where Vincent's Brigade held their ground so manfully on the afternoon of Thursday, July 2, 1863, and

Round Top proper, where the Sixth Corps of the Army of the Potomac intrenched during the night of the 2d and the morning of the 3d,) my attention was directed to a singular example of weathering which was so entirely novel to me, that I determined to secure specimens of it for exhibition to this Society as well as the Academy of Natural Sciences.

It seems to open to me a new view of concretionary structure as well as surface weathering, and is an important item for consideration when the rock is intended for building purposes.

The fracture of these rocks (and indeed of all rocks) should be subdivided into—

1. Fracture on *large* planes.
2. Fracture on small planes.

It is essential to know whether reference is made to large or small planes when the kind of fracture is described in all rocks, for though the general habit of the large plane may be a curved surface where this is shown in the original boulder, the smaller fragments may exhibit splintery, earthy, or any other fracture.

Several of these large boulders are visible in the "Devil's Den," which present 100 square yards or more of surface, and in one or two cases where the fracture seems to have been recent, the surface is very homogeneous, the curve very smooth, and the rock very sound and hard, and with a bluish gray color entirely different from the brown which it assumes in places where it has been more exposed to the weather.

In some of these latter specimens it would be difficult to persuade the eye that the object was not a Cyclopian wall of rounded and square blocks built up by the hand of man, nor is the delusion dispelled by a close examination of the rock. The spaces between the apparently separated blocks are seemingly in need of "pointing up," but otherwise there seems to be a material at the junction different from the mass of the rock.

At one blow of the hammer a shell varying in thickness from $\frac{1}{4}$ to $\frac{3}{4}$ inch and discolored by weathering, though not friable, falls off and the surface beneath is seen to be of normal structure, texture and tenacity.

One curious part of this phenomenon is the tendency of the weathered surface to become conchoidal, even where the face of the rock is plane. It results from the gradual sinking of the outside surface towards the depressions that form the divisions between the separate blocks. The mode of formation of these curious false walls appear to be first, the gradual solutions of parts of the Labradorite matrix between the hornblende crystals.

Certain lines are more readily soluble than others, and these gradually deepen as the troughs that are formed conduct more water over the most yielding parts. The small crystals of hornblende in such troughs after losing their support falls out and are washed away, and at the same time the sides of these miniature troughs being constantly subjected to the solvent action of running water and the trituration of the suspended matter

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible] INSTITUTION

[illegible] Philosophical Society, [illegible]

[illegible], Penna., Nov. [illegible]

Dr. [illegible]

Dear [illegible] — In the [illegible] of the "Popular Science Monthly" [illegible] article relating to your paper upon the subject of "[illegible]," as a [illegible] of one of the tribes of Indians inhabiting California.

The same [illegible] contains the subscribe a "Pai-Utes," shown in the [illegible] Pai-Utes, living between Montana and Pai-Utes Sioux, Indians. The [illegible] are the only to the locality [illegible] and [illegible] in the [illegible] to [illegible] tribe a reality. While attached to Dr. [illegible] Institution of [illegible] I am afforded opportunity to investigate [illegible] pertaining to scientific subjects, and I have shown [illegible] to [illegible] to the habits, customs and surroundings of the [illegible] tribes through whom [illegible] we passed.

The [illegible] alluded to is described by this subscribe a "Pai-Utes," [illegible] between [illegible] and [illegible] was [illegible] and [illegible] [illegible] Indian being their stronghold, and is [illegible] [illegible] the [illegible] Trail." By means of an interpreter, I [illegible] the following information. [illegible] the dwell of one of these [illegible] of wood is prepared in the [illegible] County. This is an [illegible] [illegible] to the height of from two to three feet. [illegible] in this which the fire is started, after which wood [illegible] across the top until the heap is [illegible] as much as [illegible]. [illegible] the [illegible] is usually [illegible], and forms [illegible] [illegible] the smoking process [illegible] [illegible] the dwelling [illegible] [illegible] the [illegible]. These last named [illegible] I have no doubt, [illegible]

may be represented to have been burnt, as the number of horses among the tribe is very small. Although, according to their belief, when an Indian dies, his spirit goes to the East, which they consider the "White Man's Hunting Ground," and where he would be unable to hunt, were his spirit deprived of these valuable aids. The remains are then *covered with earth*, whether really *buried* I could not ascertain.

Amongst the Sioux, when an Indian hands to another a stick, it implies a horse, and as soon as the recipient hands the stick to the donor (when at the latter's camp) the horse is given in return. This custom is only observed while a party have collected to dance, and the object is, that when an Indian is rich enough to be able to give away a horse, his vanity is so immense, that he must relate his brave deeds, (Count his Coos) and for the purpose of having at least one admirer upon whom he can depend for applause, and flattering notices, as "How brave!" a noble Dacotah! etc., etc., he looks over the assemblage in a dignified manner and presents some one present with a stick of wood (about a foot in length, and thick as a finger,) for which a horse will be given on the following morning.

A similar custom *might*, partially be used, to, so to use the term, burn a horse in effigy, thereby saving a *poor* tribe a valuable member; for I must say the horses are the better of the two. I have seen and been amongst probably thirty sub-tribes, but the Pah-Utes, of the above named region are the only ones with whom we came in contact, who "Cremate."

Very sincerely,

W. J. HOFFMAN,
103 S. Sixth street.

Stated Meeting, December 18*th*, 1874.

Present, 17 members.

Vice-President, Mr. Fraley, in the chair.

A letter accepting membership was received from Mr. A. Selwyn, dated Montreal, Dec. 8, 1874.

Letters of acknowledgment were received from the Royal Observatory, at Prag, Oct. 8, (XV, i, 90, 91); the Batavian Society, at Rotterdam, Sept. 26, (89); and the Victoria Institute, London, Nov. 28.

A letter inviting subscription to three sheets of photographic portraits of members of the Hungarian Academy, was received from M. L. Aigner, Buda-Pest.

A letter of envoy was received from the Linnean Society, at Bordeaux.

A letter declining to sit upon the Meunier Committee, on account of necessary and imperative engagements, was received from Prof. Guyot. A similar communication being received from Prof. Cook, the committee was discharged from consideration of the subject.

Donations for the Library were reported from the Royal Batavian Academy and Observatory; the Society at St. Gall; the Revue Politique; Nature; the Meteorological Committee of the R. Society; Essex Institue; Boston Natural History Society, and Mr. Edmund Quincy; Prof. Alfred Mayer; American Chemist; Penn Monthly; Medical News; College of Physicians; College of Pharmacy; Mr. Isaac Lea; Historical Society of Maryland; U. S. Commission of Fisheries; Engineer Department, U. S. A.; and Surgeon General, U. S. A.

An obituary notice of Chief-Justice Read was read by Mr. E. K. Price.

A communication on the alleged Parallelism of Coal-beds, by John J. Stevenson, was read by the Secretary.

The appropriations recommended by the Finance Committee were adopted.

Pending nomination 764, and new nomination 765 were read.

On motion of Mr. E. K. Price, a Standing Committee of Botanists to supervise the purchase and planting of trees for the Michaux Grove, in Fairmount Park, purchased out of the Michaux fund proceeds, was appointed, consisting of five members—Mr. A. H. Smith, Mr. C. E. Smith, Mr. Thomas Meehan, Dr. J. A. Leidy, and Dr. J. L. LeConte.

On motion, a committee of three was appointed to consider the subject of the communication made to this Society by the Baron de la Roncière de Noury, at the last meeting, consisting of Prof. Lesley, Mr. Briggs, and Prof. P. E. Chase.

And the meeting was adjourned.

Tho following letter furnished for the minutes by Mr. Price, will explain the history of the purchase of the oaks in Europe.

OFFICE OF CHIEF ENGINEER,
OF FAIRMOUNT PARK,
Philadelphia, Dec. 10th, 1874.

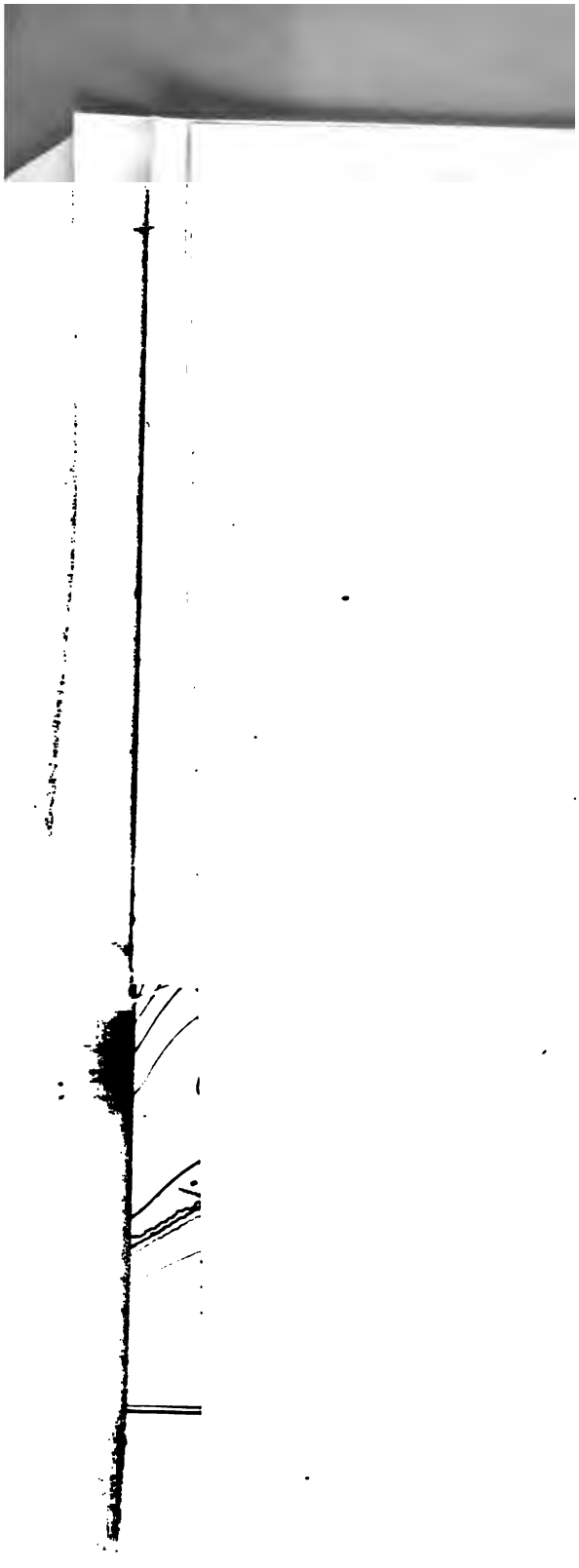
HON. ELI K. PRICE,

Chairman Com. on Nurseries, &c.

Dear Sir:—One of the objects aimed at in establishing the Michaux Grove and Nursery, was to have in the Park not only a school for study, in which might be seen trees, of valuable quality, but also the means of detecting the spurious and unreliable varieties which are sold for pure species. In order to do this, we should be able to show every variety of Oak that will live in this climate, including the sports with the names attached by respectable nurserymen at home and abroad. This is just what I have endeavored to do. Immediately after the resolution by Park Commission, of May 14th, 1870, authorizing the expenditure of $500 for Oaks, several respectable arborists were consulted as to where a collection of Native Oaks could be had, and the result was to get some 12 or 15 species of American Oaks, being all that I found in American Nurseries differing from well-known species already growing in the Park. Several young trees of each of these species were bought and planted on the site selected for a Michaux Grove. Catalogues were then procured from several foreign Nurseries, naming over 100 species and varieties of the genus Quercus. On my visit to England, in 1872, Dr. Hooker, the learned Director of Kew Gardens, was consulted, and several of the largest British Nurseries were visited, and over 80 so-called species and varieties of Oaks were examined. On my next voyage in 1873, other nurseries were visited, and then the first order was given for foreign trees, embracing from 3 to 6 plants of each of some 100 species and varieties and sports, with the names they bore in the catalogues of the most respectable Nurseries. When the invoices were received, it was evident that some of the names were misspelled. As the requisite corrections could not be made at the time, the bills were laid before the Park Commission for payment, the names forwarded in the English invoices were unchanged with the expectation of having the proper corrections made at an early day. The work of correction was commenced, but has been interrupted by my illness, and thus the uncorrected lists were unexpectedly laid before the Philosophical Society. The examinations made during my illness. show that a large proportion of the names are to be found in the list published by Paxton in his Botanical Dictionary, and also in that most complete descriptive work, the Arboretum, of London, and also, elsewhere. While I have been preparing this statement in a condition of great suffering and almost of helplessness from the violence of continued pain, my wife has kindly marked 49 of these identified names with descriptions from which any expert Botanist may recognise the plants. This work of identification, Mr. Estabrook is quite willing to undertake as soon as the spring shall bring out the foliage.

Truly yours,

JNO. C. CRESSON, *Chief Engineer.*



PROCEEDINGS

OF THE

AMERICAN PHILOSOPHICAL SOCIETY,

HELD AT PHILADELPHIA, FOR PROMOTING USEFUL KNOWLEDGE.

VOL. XIV. JANUARY TO JUNE, 1875. No. 94.

CONTENTS.

PAGE.

The Resources, Productions, and Social Condition of Spain, by Alexander Delmar 301
Gravitating Waves, by Pliny Earle Chase 344
An Obituary Notice of Mr. Joseph Harrison, Jr., by Coleman Sellers 347
An Obituary Notice of Charles B. Trego, by Solomon W. Roberts.. 356
Analyses of Rocky Mountain Coal, by J. Bledgett Britton and C. M. Cresson 358
Synopsis of the Vertebrata of the Miocene of Cumberland County, New Jersey, by E. D. Cope 361
Origin of the Lower Silurian Limonites of York and Adams Counties, by Persifor Frazer, Jr., A.M 364
Notes on the Geology of West Virginia, No. II, by Jno. J. Stevenson 370
On the Traps of the Mesozoic Sandstone in York and Adams Counties, Pennsylvania, by Persifor Frazer, Jr., A.M 402
On Cremation among the Digger Indians, by W. J. Hoffman, M.D. 414
Lunar Monthly Rain-Fall in the United States, by Pliny Earle Chase 416
Stated Meeting, January 1 418
Stated Meeting, January 15 421
Stated Meeting, February 5 422
On the Transit of Venus as observed by Mr. Davidson at Nagasaki. 423
Stated Meeting, February 19 426
Stated Meeting, March 5 428
Description of some Microscopic Sections of Trap Dykes in the Mesozoic Red Sandstone of Pennsylvania and Connecticut, by Persifor Frazer, Jr., A.M 430
Stated Meeting, March 19 432
Stated Meeting, April 2 434
Stated Meeting, April 16 435
Stated Meeting, May 7 437
Stated Meeting, May 21 439
Contributions from the Physical Laboratory of the University of Pennsylvania. No. I. A New Vertical-Lantern Galvanometer, by George F. Barker, M.D 440

THE RESOURCES, PRODUCTIONS AND SOCIAL CONDITION OF SPAIN.

By Alexander Delmar,

LATE DIRECTOR OF THE BUREAU OF STATISTICS OF THE UNITED STATES, ETC.

(*Read before the American Philosophical Society, January* 15, 1875.)

Introduction.

Until very lately there were few or no histories or works of reference in the English language relating to Spain which contained any information with regard to that country later than for the period 1855-61; and a survey of the condition of Spain from the stand-point thus afforded presented but a gloomy prospect. During the sixty-one years ending with the latest date to which these works bring the student, the population of Europe and America had nearly doubled, and this increase in the numbers of the foremost races of the world was, as it always is, merely the type of that vast and almost universal material progress which renders such increase possible.

During the same momentous period, serfdom and slavery had been condemned or abolished in both continents, and with it the feudal system and the corvée. During the same time mankind had armed itself with the titanic powers of steam and electricity, and rushed with renewed strength into that perpetual struggle with nature, which is its heritage, but in the maintenance of which, at about the beginning of the period referred to, it had become well-nigh exhausted, for lack of suitable weapons and appropriate agencies. This epoch, too, had witnessed in many countries the separation of Church and State, the obliteration of castes, the spread of popular education, the establishment of popular representation, the mobilization of proprietary rights, the development of great scientific progress, and a brilliant series of discoveries in every department of thought.

During all this time, marked by the mightest strides of material progress which the world had ever seen, that country of Europe which, while the rest of the Continent was shrouded in the darkness and bigotry and superstition of the Middle Ages, once held aloft the lamp of science and built up with the hands of its Semetic occupiers a civilization several centuries in advance of its time; that country from which subsequently went forth the imperial dicta that controlled one-half of the Continent, and all of the newly discovered world beyond the Western Ocean, lay inert and motionless.

The country of Abderrahman, of Alfonso el Sabio, of Ximenes, had made no sensible progress for centuries. The numbers of the people were substantially the same, the institutions were the same, the lives they led were the same. So late as the year 1855 but one-fifth of the surface of Spain was cultivated; the rest had been blasted by a ruinous system of exploita-

tion. A great portion of the entire country, cultivated and uncultivated, was owned by the Church and nobility. The Inquisition had been but recently suppressed; the peasantry were still in a condition of serfdom, the corvée was in vogue, the country swarmed with drones, bandits, smugglers, vagabonds and beggars; religious liberty was denied, and popular education was almost wholly unknown. There was no scientific development; no well-established middle class, and but the beginnings of a newspaper press and a railway and telegraph system. There were few or no roads, or manufactories, while commerce was restricted, and free discussion prohibited. In a word, Spain, though she had made more than one abortive attempt to do so, had not yet fully awakened from the torpid condition into which she had been cast ages before by the cold hands of ambitious, unpatriotic and selfish ecclesiastics. The rest of the world had long since awakened to a life of freedom and joined in the race of modern development; Spain was still asleep, drugged with the fumes of prescribed ignorance and dictated intolerance.

It is not held that this was truly the condition of Spain so late as up to 1855-61; but that this is substantially the picture of it that is to be found in many of the most authoritative and latest works of reference now extant in our language on the subject.

The following view of Spain was written during the reign of Ferdinand VII—about forty or fifty years ago (Macgregor, 994):

"Exclusive of about a fourth of the population, composed of persons living on their property without doing anything, Spain, according to the census of 1797, contained 100,000 individuals existing as smugglers, robbers, pirates and assassins, escaped from prisons or garrisons; about 40,000 officers appointed to capture these, and having an understanding with them; nearly 300,000 servants, of whom more than 100,000 were unemployed, and left to their shifts; 60,000 students, most of whom begged or rather extorted charity at night, on the pretence of buying books, and if to this melancholy list we add 100,000 beggars, fed by 60,000 monks at the doors of their convents, we shall find that at the period referred to, there existed in Spain nearly 600,000 who were of no use whatever in agricultural or the mechanical arts, and who were only calculated to prove dangerous to society. Lastly, having made these and other necessary deductions, we find that there remained 964,571 day laborers, 917,197 peasants, 310,739 artizans and manufacturers, and 34,399 merchants, to sustain by their productive exertions 11,000,000 of inhabitants. These results which, *mutatis mutnndis*, are applicable at the present day as at the time when they were deducted, exhibit a state of society so radically corrupt and debased as to render all hopes of its regeneration very nearly desperate."

Said M'Culloch, writing in 1844: "Owing to vicious institutions, bad government and other causes, Spain has, for a lengthened period, continued stationary or made little progress, while other nations have advanced with giant steps in the career of improvement."

Said Macgregor, in 1850: "The government of Spain can scarcely be considered less despotic than Russia or Turkey;" and he goes on to speak of "the backward state of agriculture in Spain, the indolence of the rural population, the great numbers who are otherwise employed than in husbandry, and the preference given to pastoral occupation over that of tillage," etc.*

Appleton's Cyclopedia, which is dated 1864, though it notices the beginnings of a recently developed appearance of progress in Spain, states that agriculture there is still in its infancy, notices the continuance of the *Mesta* and other institutions of the Middle Ages, and chronicles the then recent conservative reaction typified by the restoration to the Church of all the lands that had not been sold.†

In brief, the picture of Spain, which is obtained from the usual works of reference on the subject, depended upon, or accessible to, the American student, is that of a Spain still sleeping the sleep of the centuries.

But this picture is incorrect. Since the date of these works, or of the information which they contain, Spain has made, what is for her, enormous progress. From absolutism to constitutionalism was for her but a single jump, and not like France in 1789 through a Reign of Terror, but by the progressive steps of an orderly and deliberate revolution. This

* The following tables, though obviously imperfect, may nevertheless afford an indication of the backward social condition of Spain previous to recent changes:

DRONES IN SPAIN.

CLASSES OF DRONES.	Year 1797. Macgregor, p. 994, and M'Culloch, 840.	Year 1826. Macgregor, p. 944, and M'Culloch, 840.	Year 1857. Martin, etc.
Smugglers, etc	100,000	100,000	.....
Custom Officers	40,000	40,000	27,922
Domestic Servants	300,000	276,000	296,090
Student Beggars	60,000	.....	47,312
Beggars	100,000	36,000	.....
Monks	61,617	61,727	125,0.0
Nuns	32,500	24,007	
Other Ecclesiastical	81,803	85,735	
Vagabonds	.....	140,000	.....
Inquisitors	2,705	22,000	.....
Officers of Inquisition	.....		
Wandering Convicts	.....	2,000	.....
Army and Navy	500,000	100,000	241,335
Nobility	350,000	.....	478,716

The classification involves questions of opinion and taste in which I am far from agreeing with the writers from whom I quote.

The following table, from various authorities, shows the ecclesiastical population of Spain at various dates:

Year.	Number.	Year.	Number.
1787	188,625	1857	125,000
1803	203,298	1862	39,885
1833	175,574	1870	.....

Without feeling at all certain of the accuracy of these numbers, I think it safe to conclude that since 1855 the porportion of ecclesiastics in Spain has very materially decreased.

† These lands were again taken from the Church and sold, the Church receiving an equivalent for them in money. During the subsequent civil war this payment was stopped. Upon the recent accession of Alfonso XII, it was resumed. The substantial point of the whole history is that the people have got the lands and no reaction can deprive them of them.

revolution, like its predecessor in the same country of half a century before, may have gone too far and subjected itself to the evils of a conservative reaction which in time will destroy all its good effects, but this is not believed to be the case. During the late years preceding and during its republican government, the Spanish nation so thoroughly destroyed the power of the bigots, so utterly abolished feudal institutions, so scattered to the winds the privileges of castes and monopolies and so clinched and riveted these reforms by the educational institutions and agencies of material progress which it created, that for it to go back to the dark ages of twenty years ago is simply impossible. Several millions of people in Spain have learned to read during the past fifteen or twenty years; several thousand miles of railways have been built; several millions of acres of additional land brought under cultivation. These are works of progress that cannot be undone. Spain is like an inert mass suddenly hurled into the illimitable space of action; she must go on now forever.*

In endeavoring to portray the recent progress of Spain, I shall confine myself in this paper chiefly, though not entirely, to the important topic of agriculture, and the sub-topics more immediately connected with that greatest of all industries. This is done not only because progress in Spain means, and must, for some ages yet, mean, necessarily and above all things, progress in agriculture; but also because it is upon this subject that current works of reference on Spain are most deficient.

Natural Resources, Climate, etc.

Of this once most foremost country of the world, it may be said briefly that nature gave her every original resource and man destroyed them all. Situate in the temperate and tropical zones, watered by two oceans, and penetrated by no less than 230 rivers, nearly one-half of her soil still lies barren, for the want of moisture denied her by the destruction of her forests. The average fall of rain during the year is stated to be "19.45 inches, while the average heat is 65° 42′ Fahrenheit, even in winter only falling to 56° 54′ and in summer ascending to 99°." U. S. Com. Rel., 1868, p. 373.

In Alicante and many other provinces it seldom rains at all. When it does, the floods are often very destructive. In November, 1864, an extraordinary inundation took place in the province of Valencia, causing the river Ircar to overflow its banks, partially destroying the town of Alcira, and inflicting damage to the amount of over two million dollars (Br. C. R. 1865, p. 73). Spain is essentially a country of mountain ridges and ele-

* "Don José Sanchez de Bazan gave me some highly interesting accounts of recent Spanish progress, and the state of affairs in his country. There were three thousand miles of railways in Spain; over twelve million passengers were annually carried upon them; there were seven thousand miles of telegraph, fifteen thousand miles of common roads, etc. The Constitution guaranteed complete civil and religious liberty: the priests were banished; the press was free, and Spain would soon once more lift up her head among the nations."—*A Summer Tour in* 1872, by Alex. Delmar. Appleton's Journal: New York, November, 1873.

vated plateaux, the former being filled with mineral riches, the latter once the scene of immense agricultural productions.

Moneys, Weights and Measures.

Previous to July 19, 1849, the weights and measures of Spain differed in every province*, though those of New Castile, the province in which the capital of the country is situated, were the ones generally employed in works relating to the entire country. The following table shows the principal moneys and principal weights and measures in use previous to the establishment of the metrical system :

Moneys, Weights and Measures—Old System.

1 Escudo,	equal to (exchange value, about)	$0.50 U. S. Gold.	
1 Real de Plata,	"	.10 " "	
1 Real de Vellon,	"	.05 " "	
1 Arroba of wine,	"	4.268 gallons.	†
1 Arroba of oil,	"	3.323 "	†
1 Aranzada,	"	1.106 acres.	‡
1 Fanegada,	"	1 591 "	‡
1 Fanega,	"	1.55 bush.	‡
1 Libra,	"	1.0144 lbs. avoir.§	

There is also a land measure used in Valencia, and perhaps elsewhere, called the *hanegada*, equal to 0.2062 acres. The *cahiz* is equal to 12 *fanegas*, or 18.6 bushels.

Moneys, Weights and Measures—New System.

Although the metrical system was established throughout the entire kingdom of Spain by the law of July 19, 1849, the old metrology continued to be employed in Spanish works so late as 1859, and sometimes it is still used. Under the present system Spanish names are given to the French moneys, weights and measures. The franc is called the *peseta;* the metre, *metro;* the litre, *litro*, etc. The equivalents of these terms are well known.

The reform effected by the adoption of the metrical system in Spain, though insignificant when compared with the far more essential reforms which will presently be alluded to, is nevertheless not altogether unim-

* For a full account of Spanish provincial metrology see book of Instructions to Spanish Consuls, a work to be found in the hands of the various Spanish consular officials throughout the world.

† Von Baumhauer.

‡ The best authorities for these equivalents are : 1. The Official Instructions to Spanish Consuls; and 2. The able paper of M. Von Baumhauer, published in the Report of the Seventh International Statistical Congress, vol. 3, p. 173. These authorities agree substantially as to the Castilian *Aranzada* and *Fanegada*. The Spanish work establishes the *Aranzada* at 4471.92644 metres; M. Von Baumhauer says 44.71918 ares. The Spanish work fixes the *Fanegada* at 6439.574075 metres; M. Von Baumhauer says 64.39533 ares. But when it comes to the *Fanega* they differ. The Spanish work sets it down at 55.101055 litres; while M. Von Baumhauer says 55.50123 litres. Other authorities differ from both of these. Deeming the Spanish official publication the highest authority on the subject, I have adopted the equivalents therein established as being the most correct. The American equivalents of the metrical weights and measures are from the invaluable little work of Dr. B. F. Craig, of Washington, D. C., which corrects the errors of the British Assay Office.

§ Von Baumhauer.

portant; for it rendered possible intercommunication and commercial dealings between the various provinces of Spain which, under the old system, were almost impossible. There were *arrobas* and *fanegas* and *fanegadas* in all the provinces, but no two were of like value, and they differed enormously. The *fanegada*, which contained 576 *estadales carrés* in Castile, contained from 100 to 625 in the other provinces, and the *aranzada*, which contained 400 in Castile, contained from 300 to 600 elsewhere. (Von Baumhauer.) With an illiterate population, such a diversity of terms was tantamount to an almost entire prohibition of intercourse between the provinces.

Total Area of Country.

In the Spanish statistical tables, Spain is usually meant to embrace the Balearic and Canary Isles. The following table gives the total superfices:

	KILOMETRES CARRÉS.	MILES.	ACRES.
Spain proper	494,946	190,257	121,764,480
Balearic Isles	4,817	1,852	1,185,280
Canary Isles	7,273	2,796	1,789,440
Total	507,036	194,905	124 739,200

Cultivated Area at Various Dates.

I have before me nine different accounts of the cultivated area of Spain at four different periods, viz.: 1. The account of Miguel Ozorio y Redin, who wrote in the last half of the seventeenth century; 2. The official returns for the year 1803; 3. An account from the *Junta de Medios*, concerning the divisions of land in 1803; 4. A statement laid before the Cortes in 1808; and 5, 6, 7, 8, and 9, various accounts relative to the divisions of land from the year 1857 to the present time. Of these accounts the earlier ones have generally been treated by English writers as more or less fanciful; on the contrary, I believe them, when rightly understood, to be more or less correct. Confusion of the terms, "productive land," "cultivable land," "cultivated land," "arable land," "area sown in grain," and "area in which grain is sown," as well as error in the translation of "fanegadas" and "fanegas" being sufficient to account for their apparent discrepancies.

Selecting the second one, as perhaps the most reliable, we have the following divisions of Spain proper for the year 1803:

DIVISIONS OF LANDS 1803.	SQUARE LEAGUES.	ACRES.
Cultivated lands and fallows	4,310	27,627,100
Pastures and commons	11,658	74,727,780
Forests and copses	1,580	10,127,800
Mountains and rivers	1,342	8,602,220
Total	18,890	121,084,900

I deem the following to be the most reliable one relative to any late year preceding the period of recent progress:

DIVISIONS OF LAND IN 1857.	ACRES.
Land sown in grain, potatoes, beans and peas, roots, vegetables, commercial crops, fallow land, grass land under rotation, chestnut groves, orchards and gardens	32,210,071
Vineyards	2,906,783
Olive grounds	2,122,730
Meadows and pastures	16,926,028
Mountainous lands	10,832,730
Sites, mines and quarries	3,586,247
Total productive land	68,584,589
Forests	6,885,600
Barren and waste; also lakes, rivers, roads, etc	49,269,011
Grand total	124,739,200

Comparing the two accounts, so far as their different classifications will enable a comparison to be made, we have the following results:

DIVISION OF LAND.	1803. SPAIN PROPER. ACRES.	1857. SPAIN AND THE ISLES. ACRES.	GAIN OR LOSS. ACRES.
Cultivated and fallow	27,627,100	37,239,584	G. 9,612,484
Forests	10,127,800	6,885,600	Loss.
Copses		.....	
Mountains	8,602,220	10,832,830	Unchanged
Rivers		Inc. in "Barren."	
Sites, etc	.....	3,586,247	
Meadows and pastures	74,727,780	16,926,028	Unchanged.
Barren, waste, etc		49,269,011	Loss.
Total	121,084,900	124,739,200	

Beyond the essential point that nearly ten million of acres were added to the cultivated lands, it can only be stated roughly that the forest lands of Spain, which, so far as concerns the period under review, were never extensive, slightly diminished; the pasture lands (properly speaking, there were few or no meadows in Spain), remained unchanged, and the common and waste lands diminished, by being brought partly under cultivation.

IRRIGATION.

Of the above mentioned 37,239,584 acres of cultivated land, 2,857,648 acres were irrigated as follows:

DIVISIONS OF IRRIGATED LAND.	FANEGADAS, EACH OF 1.60 ACRES.	ACRES.
Arable land	1,370,090	2,192,144
Vineyards	67,374	107,755
Olive grounds	74,618	119,389
Other	273,970	438,360
Total	1,786,025	2,857,648

Land Sown in Grain and Potatoes.

Of the 32,210,071 acres of land devoted to grain and other products, or in fallow, the following portions were sown in grain and potatoes only:

Wheat	7,311,892	acres.
Barley	3,182,100	"
Rye	2,961,863	"
Maize and other grain	1,351,687	"
Potatoes	509,503	"
Total	15,316,865	"

The divisions of land in 1874 are estimated as follows:

Divisions of Land in 1874.	Acres.
Cultivated and fallow:	
Arable land, *i.e.*, land sown in various crops, fallow land, grass under rotation, groves, orchards and gardens	40,000,000
Vineyards	3,000,000
Olive grounds	2,000,000
Meadows and pastures	17,000,000
Mountainous land	10,800,000
Sites, mines and quarries	3,700,000
Forests	6,800,000
Barren, waste, public and water surfaces	41,439,200
Total	124,739,200

The cultivated and fallow lands, which amounted to less than 28,000,000 acres in 1803, and about 37,000,000 acres in 1857, now amount to 45,000,000 acres; showing as great progress during the seventeen years from 1857 to 1874 as occurred in the fifty-four years from 1803 to 1857. According to this measure, progress has been thrice as rapid during recent years as it was previously.

Population.

According to Martin, Spain, in the time of Julius Cæsar, contained a population of 78,000,000; according to a Spanish author quoted in the U. S. Com. Rel., 1865, p. 169, she had 68,000,000; according to Appleton's Cyclopedia she had 40,000,000. I place no reliance whatever on these conjectures. Seaman's Progress of Nations, p. 551, also contains a series of conjectures on the subject which are certainly wrong or fallacious. The carliest authentic account of the population of Spain, dates about five centuries ago, when under the Moors, she was stated to have contained 21,700,000 inhabitants. This account—from the number and opulence of her towns, the works of improvement executed and which still remain, the breadth of land cultivated, the number of houses, workshops, artisans, etc., all of which are known with reference to many localities,—this account I believe to be substantially correct.

Through the expulsion of the Moors, who were the agriculturists, and the Jews, who were the manufacturers and merchants of Spain, this vast population, which, in my opinion, is the greatest the soil of Spain ever

supported, gradually dwindled down to about 7,600,000 inhabitants in 1723. From the last named period it has very slowly increased to somewhat over 17,000,000 at the present time.*

The following table exhibits the data on this interesting subject, together with such remarks as I have deemed were necessary to be made and the authorities from whom I have quoted. I have indicated the figures which I consider incongruous by placing them in brackets.

POPULATION OF SPAIN AT VARIOUS PERIODS.

(The figures in brackets do not appear to agree with the others.)

Year.	*Population*	*Authority.*	*Remarks.*
13th Cen.	21,000,000	Rep. Br. Sec. Leg., 1866	Quoted from Spanish author
1380	21,700,000	Castile 11,060,000, Arragon 7,000,000 and Grenada 3,000,000	.....
1594	8,206,791	Rep. Br. Sec. Leg., 1866	.....
1618	[9,000,000]	Cevallos	Quoted by Macgregor.
1618	7,500,000	Ustariez	Quoted by Macgregor.
1688	[8,000,000]	U. S. Com. Rel., 1865	.....
1700	[8,000,000]	Macgregor	At death of Charles II.
1723	7,625,000	"	From an official census.
1726	[5,423,000]	"	Excludes nobility and clergy
1768	9,307,800	Com. Rel., 1865	.....
1769	9,301,728	Macgregor	Includes Canaries and African settlements.
1770	9,307,000	"	
1788	10,143,000	"	Excludes Canary Isles.
1789	10,761,485	Com. Rel., 1865	Includes Canaries, etc.
1797	10,541,000	Appleton's Cyc.	.....
1797	[12,000,000]	Com. Rel., 1865	.....
1803	10,351,000	Macgregor	Census, Spain proper.
1803	10,351,075	U. S. Census, 1850, p. xxxiv	Spain and Balearic Isles.
1820	11,000,000	Com. Rel., 1865	.....
1821	11,248,000	Macgregor	Census, Spain proper.
1821	11,248,026	U. S. Census, 1850	" " "
1823	12,000,000	Com. Rel., 1865	.....
1826	[13,712,000]	Macgregor	Cadastral ret'ns, Spain pro'r
1827	[13,953,957]	"	Cadastral ret'rn, Spain and Balearic.
1828	[13,698,000]	Com. Rel., 1865	Martin says 13,698,029.
1833	12,087,991	Ency. Amer., vol. 14	Official. Excludes Balearic..
1833	12,386,841	Alm. de Gotha, 1850	Official. Includes Balearic and Canary Isles.
1834	[14,660,000]	Macgregor	Estimated.
1834	12,232,194	U. S. Census, 1850	From Guibert.
1834	12,168,774	"	From M'Culloch.
1837	12,222,872	Martin	.....
1842	12,054,000	"	.....
1846	12,166,774	"	Includes isles.
1849	13,705,500	Alm. de Gotha	Spain proper.
1850	[10,942,280]	Br. Rep. Sec. Leg	Incorrect.
1857	14,957,575	Alm de Gotha	Spain proper.
1857	[15,807,753]	Martin	Spain proper. Details given.
1859	15,460,000	.....	Estimate.
1860	15,673,481	Rep. 7th Inter. Stat. Cong., vol. 3..	The enumeration dates Dec. 31 in each year.
1861	15,867,304	" " " " "	
1862	16,043,703	" " " " "	
1863	16,180,183	" " " " "	
1864	[15,752,607]	Br. Stat For. Coun	Spain proper.
1864	16,302,148	Rep. 7th Inter. Stat. Cong. vol. 3..	The enumeration dates Dec. 31 in each year.
1865	16,378,481	" " " " "	
1866	16,526,474	" " " " "	
1867	16,656,879	" " " " "	
1868	16,732,052	M. S. 21-41-2-349	.....
1868	[16,990,550]	Br. Stat. For. Coun	Spain proper.
1869	16,800,000	Estimate	Spain proper.
1870	16,935,613	Br. Stat. For. Coun	Spain proper, census returns.
1871	17,000,000	Estimate	Spain proper.
1872	17,100,000	"	Spain proper.
1873	17,200,000	"	Spain proper.
1874	17,300,000	"	Spain proper.

* It is believed by some writers that the population of Spain again retrograded subse-

This is a most instructive table.

First. It shows an extraordinary decrement of the population of Spain from about the beginning of the fifteenth century until after the beginning of the eighteenth. This is attributed chiefly to the Moorish and Jewish exodus which commenced to take place in the year 1492, the same year in which that New World was discovered in which eventually so many of the exiles found both homes and religious liberty. From first to last it is supposed that no less than 300,000 Moorish and 300,000 Jewish* families, or nearly three millions of intelligent and industrious people were driven from Spain, and amidst the most shocking cruelties. These, together with the numbers who fled after the conquest of Grenada and the colonists to America, contributed to reduce the population from nearly 22,000,000 in the fourteenth century to little more than 7,000,000 in the seventeenth. Notwithstanding the persecution of the Moors and Jews, it is stated that considerable numbers remained in Spain, professing, if not believing, in the doctrines of the Church, and forming the bulk of the agricultural and industrial classes in many localities. This is affirmed by Macgregor and denied by Buckle, but I think the weight of evidence is with the former. M'Culloch, p. 845, says there were 60,000 Moriscoes in Grenada in his time, about the year 1840.

Evidence of the large population that dwelt in Spain under the Moorish régime is found in a class of facts, of which the following are examples:

"Before the Conquest in 1487 (the city of) Grenada had 70,000 houses and 400,000 inhabitants, 60,000 of whom were armed. It was defended by ramparts flanked by 1030 towers and two vast fortresses, each of which could receive in garrison 40,000 men.

"The kingdom (of Grenada) of which it is the capital, was only thirty leagues in breadth by seventy in length, but it contained thirty-two large cities and ninety-seven towns and 3,000,000 of inhabitants. The whole population at present does not exceed 83,000.

"The city of Cordova under the Moors occupied nearly eight leagues of the banks of the Guadalquiver, and contained 600 grand mosques, 3,837 small mosques or chapels, 4,320 minauts or towers, 900 public baths, 28 superbs, 80,455 shops, 213,070 dwelling-houses, 60,300 hotels or palaces." *Moreau de Jonnés*, 1834.

"The last official census states that 1,511 towns and villages were then totally uninhabited and abandoned." Macgregor, 1850.

For further evidence on this point, consult Buckle's *Hist. Civ.*, Draper's *Hist. Civ.* and *Civil Policy of America.*

Second. The table of population shows a very slow increment from the

quent to the year 1830. This opinion is probably based on the cadastral returns of 1826, or thereabouts, and the smaller numbers of the census returns of 1833. It may be well-founded; but I have ventured to disregard it in arranging the figures of the text.

* This is the highest estimate. Buckle, who quotes a number of authors, states that the number of Jews actually expelled is differently estimated at from 160,000 to 800,000. —*Hist. Civ.*, ii, 15.

beginning of the seventeenth century to about the year 1850. The population is stated to have been 7,500,000 in the year 1618 and 13,705,500 in 1849. This is an increase of but 82.7 per cent. in 231 years!

Third. The table shows a comparatively rapid increment of population since about the year 1850, to-wit: from 13,705,500 in 1849 to about 17,300,000 in 1874, an increase of 26.2 per cent. in 25 years. This is the period of recent progress in Spain to which attention has been directed, and it is believed no better proof can be adduced in support of this allegation of progress than the rapid increment of population which, in spite of foreign and civil wars, has taken place.

Rural and Civic Population.

The cadastral returns of 1826 gave the rural population at 80.4; the civic at 18.5, and the ecclesiastical at 1.1 per cent. of the whole. The proportion of rural population therein shown is probably correct at the present time.

Agricultural Population.

Spanish statistics, at least as they reach compilers outside of Spain, are proverbially incomplete, contradictory and obscure, and they are no less so on this simple subject than on any other which I have found it necessary to examine. The agricultural population of a country but half cultivated, and that portion but indifferently tilled—a country, which, as a rule, has forbidden the importation of breadstuffs, while it had none to export; which is neither a pastoral nor a new country; and in which the struggle for subsistence is so great that a local and temporary drought is enough to stimulate what is else a constant but sluggish stream of emigration to other countries—ought to be uncommonly large. On the contrary, my information states it to be comparatively small. If the latest figures before me are corrrct, the agricultural population of Spain is but 55 per cent. of the whole; whereas I am confident it is not less than 65 to 70 per cent. The following is the statement:

Occupations of the Population of Spain, 1857.

Non-Agricultural Male Adults.		Number.
Army, Navy and Military functionaries		241,335
Officials: State	22,363	
Municipal	62,976	
Provincial	4,693	
		90,031
Nobility		478,716
Clergy		125,000
Students	47,312	
Advocates	5,673	
Writers	9,351	
		62,336

Non-Agricultural Male Adults.	Number.
Servants	206,090
Merchants	119,234
Scientific	35,736
Artists and mechanics	88,728
Manufacturers	67,327
Miners, (1864)	32,201
Workmen in refining and smelting works, (1864)	9,945
Fishermen, 1866	39,440
Seamen in ports, harbors, etc., 1863	11,285
" foreign trade, 1863	16,181
" coasting trade, 1863	21,606
Total	1,645,191

Total able-bodied men, 3,803,991. This would leave, at the most, but 2,158,800 agriculturists. At an average of four inhabitants to each able-bodied man, this would imply, at the most, an agricultural population of 8,632,000, which is 55 per cent. of the whole. Add to the 2,158,800 male adult agriculturists about 340,000 female laborers, and we have in round numbers 2,500,009 persons actually employed in agriculture. This number forms less than 16 per cent. of the whole, a proportion that, taking into consideration the rude state of tillage in vogue, would seem entirely inadequate to produce the requisite amount of food for all.

Macgregor (p. 944) publishes the details of a cadastral return of the population for 1826, concerning the correctness of the total sum of which there is perhaps some doubt. The total figure is 13,712,000, while the total of the table of details is but 13,211,301. In this table the agricultural population is placed at 1,836,320 heads of families and others, and 6,777,140 women and children, the first-named figure being 13.9 per cent. of the whole and the latter 65.2 per cent. The details of heads of agricultural families and others are as follows: Proprietors, 364,514; farmers (middle men), 527,423; laborers, 805,235; proprietors of herds and flocks, 25,530; and shepherds, 113,628.

I am inclined to believe these proportions to be nearer the truth, and the truth at the present time, than those deduced above.

The discrepancies have doubtless arisen less from any material changes in the occupations of the people than from the fact that in many districts the agricultural laborer often alters his trade during the year; so that the agreement of two censuses would depend largely upon the time of the year they were taken respectively. (See on this point, L. T., 24, § 9.)

Female Laborers.

In Galicia and Asturias the number of female laborers is nearly equal to the male. These districts comprise about one-fifth of the population. In Carthagena, province of Murcia, population 380,969, female labor is seldom or never employed for field work. In Minorca female labor is employed hardly at all. In Majorca it is employed. Female laborers are

employed, but not generally, in Guipuzcoa, Basque Provinces, population 162,547. In Biscay, Basque Provinces, population 200,000, all the females work in the fields at times, and female labor is largely employed. In the Provinces of Malaga, Granada, Almeria, and Jaen, population 1,565,979, female labor is hardly at all employed in the cultivation of land, only in gathering olives and cutting grapes. From these and other reports (Land Tenures, Part III), I have ventured to estimate the number of female laborers in Spain at about 340,000, though I dare say the true number is upwards of 500,000.

Land Tenures.

The laws of 1820 abolished the right of primogeniture and all other species of civic entail (*mayorazgos*); then followed that of 1841 on ecclesiastical benefices, and finally that of 1855, which declared in a state of sale land and house property belonging to the State or appertaining to corporations of towns, beneficence, public instruction, clergy, religious fraternities, pious works, sanctuaries, etc. Like many other reforms which have taken place from time to time in Spain, certain provisions of this one were rescinded, and it was not until 1865 that the Crown lands were finally decreed in a state of sale. It is, however, from the year 1855 that the freedom of Spain from religious and feudal tenures really dates.

When it is considered that these tenures were abolished in France by the Revolution of 1789, in the United States, generally, during the earliest days of their history as independent Commonwealths, and in Prussia in 1820, it cannot be deemed strange that a country which did not succeed in throwing them off until 1855 should have failed to show any signs of progress until within very recent years.

The condition of affairs in 1840 is thus described:

"Mr. Townsend (ii, 238) mentions that the estates of three great lords —the Dukes of Osuna, Alba, and Medina Cœli—cover nearly the whole of the immense Province of Andalusia; and several in the other provinces are hardly less extensive." M'Culloch, p. 837.

"The great estates belonging to the corporations, or towns, are held in common; and in consequence are wholly, or almost wholly, in pasture." —*Ibid.*

In 1850, we have the following account:

"Among the causes of the defective state of agriculture in Spain are the tenures of land. The unalienable, indivisible *mayorazgos* (entails) are considered as having for a long period comprised, including the property of the Church, about *three-fourths* of the territorial surface of Spain.

"The *Mesta* is another great, although secondary, cause of the neglect of agriculture. This is the name of a great incorporated company of nobles, ecclesiastical chapters, persons in power and members of monasteries, who were authorized to feed their flocks, at scarcely any expense, on all the pastures of the kingdom, and have almost an imperative special code of laws (*Leyes y Ordenenzas de la Mesta*) for maintaining their originally usurped privileges. It holds its courts and has numerous Alcaldes,

Entregadors, Quadrilliers, Achagueros, and other law officers. Within the last five years, the *Mesta* has possessed about half of the sheep in Spain." Macgregor, p. 1016.

For lists of the religious establishments and the enormous properties and revenues they absorbed, see pp. 1023–5 of the same work.

As to the condition of affairs at the present time, the bulk of agricultural lands in Spain appear to be still held by wealthy or noble proprietors, who live in the cities and lease them out on half produce, *a la meta*, to indigent peasants. Feudal tenures are indeed swept away, but many of the features of feudality remain, and it is still the custom in Alicante and perhaps elsewhere, for the metayers to present the proprietors with a certain number of fowls each year. The custom is now voluntary and by no means relished by the owner, who feels bound to make some return; but it serves to indicate the relations between the metayer and his landlord. The metayers on rice plantations in Valencia pay one-third produce. Certain rights of commonage appear to continue. (L. T., 40, § 7.) In Galicia, the "foro" is mentioned so late as September 30, 1870. (Com. Rel., 1871, p. 1008.) The "foro" is a sort of land impost created some eight or nine centuries ago, and continues to be paid annually by the present owners to the descendants of the former proprietors of land. "The importance of this tribute is such that it sometimes absorbs the total productions of the soil; thus it is that two-thirds of it has never been cultivated." (*Ibid.*?) In October, 1873 (Com. Rel., 1873, p. 946), it is stated that the feudal tribute of "foro" had been declared redeemable by the Government.

In fine, Spain may be said to have scarcely even yet emerged from the feudal state. A large portion of her soil is still owned by absentee landlords and rented, partly for money rents and partly *a la meta*. The proprietors seldom sell their properties (L. T., 42, § 10), and there is no compulsion on their part to sell, lease, or otherwise dispose of their property to peasants or others. (L. T., 49, §§ 6–7–8.) But as the law of descent and division is the same that applies to personal property (*Ibid*, 43, § 2), it is merely a question of time when they will be divided and absorbed by peasant proprietors.

Another drawback is the allodial duty of two per cent. on the sale of lands. (L. T., 31.) There is a government duty of three per cent. on all transfers of property (p. 47, § 13). Whether the allodial duty of two per cent. is added to this, does not seem clear.

But the great fact remains that the feudal system and all entails are abolished; the lands of the religious establishments and the Crown* are sold, the corvée and the mesta swept out of existence, small peasant properties exist in large numbers all over the country, and the door is opened to further reform and future progress.

* In 1866 laws were also passed to facilitate the sale of mountainous lands.

Laws of Succession.

Land may now be willed as the owner chooses provided he has no children. In case he has, these are his natural heirs, and the division is in equal parts. He can, however, dispose of one-fifth thereof in favor of his widow, or some particular child, or even of a stranger. Should the property have increased in value since the marriage day of the owner, his widow has a right to the half of the increase (L. T., 19). While this is stated to be the law of Spain, the same authority speaks of the existence (Dec. 7, 1870) of separate codes of law affecting real estate in different provinces. (See pp. 40 and 43.) But this I doubt. The law of descent seems now to be general throughout the land, and to have been based on Novela cxviii of the Roman laws of Justinian.

Mortmain.

The abolition of mortmain (law of *desamortizacion*) took place in 1855, but many persons refused to buy church property on account of religious scruples. In 1858 the Pope's sanction was obtained, when the sales were actively continued, the Government giving great facilities to the purchasers. The payments are made one-tenth in cash and the remainder in promissory notes running from one to ten, and in some cases, nineteen years, and secured by mortgage on the property. Owing to these facilities of purchase the biddings have often more than twice exceeded the true market value of the parcels put up. The churches, etc., receive compensation for their lands thus sold, and the nation gains by the operation, what benefit accrues from throwing open lands to peasant ownership and industrious tillage, which had been either entirely sequestered or negligently worked by metayer tenants subject to the church. About $100,000,000 have been paid (in Government stock) to these institutions for their lands, and about $200,000,000 (in cash and mortgages) received from the purchasers. The total payments (for the operation has not yet quite ceased) are estimated at $125,000,000, and total revenues at $250,000,000; so that the Government will have made $125,000,000 by the law of mortmain. The interest on the payments to the religious establishments, which were made in Government securities, was stopped during the Republic, but an order for its resumption was among the first acts of Alfonso XII upon his accession to the throne of Spain in January, 1875.

Registry System.

"The sale or transfer of property (land) of every sort is always (now) done by deeds drawn up by a notary and inscribed in the Land Register. Leases of smaller importance are made by contract before witnesses. A tax of two per cent. is paid to the State in cases where property is held (hired?) or transferred; but where a son inherits directly from his father, or *vice versa*, no succession duty is paid. It exists, however, when the inheritance is from any more distant relative and increases proportionately." *Report of Percy Ffrench, First Sec. H. B. M. Legation in Spain.* L. T., 18.

Property is still administered and managed in Spain with great disorder and negligence, and extreme irregularity exists in the registration of leases, etc. This is probably due to the heavy registration, succession and other fees, and attempts to avoid them by neglecting proper formalities. Stamped paper must be used; only a feed notary can draw the papers, and fees attend every step of registration, search or certification. The average cost of transfer is about one and a-half per cent. *ad valorem.* (L. T., p. 44). In other respects the registry system, which has only been in force since 1863, appears to be similar to that which has always existed in the United States.

Hypothecation of Real Estate.

The very recent abolition of feudal and ecclesiastical tenures, the continued monopolization of the land by the wealthy (L. T., p. —), the newness, the exactions and disorder of the registry system, together with other causes, combine to render difficult the hypothecation of real estate. In cases where these obstacles do not exist, where the title is undoubted and the land held in fee, there is no difficulty in obtaining loans to the extent of one-third to two-thirds the value of the property, at six to ten per cent. per annum. But in most cases it is the landless metayer who desires to borrow and has nothing to offer as security but his growing crops. Upon such a precarious basis, ten to fifteen per cent. is a low rate to charge for interest, and often from thirty to forty per cent. is paid. (L. T., 18). With the means thus obtained numerous small holdings of mountain land (common land sold by Government under act of 1866) have been purchased by the peasantry on seven year annual installments (p. 30). This points to an extension of the same sort of spade culture which is to be seen in the hilly parts of Italy, and to the abandonment of the better but metayer-held lands of the nobility—a tendency that should not exist.

Positos.

"*Positos*" are described by Macgregor as a sort of co-operative society to supply seed corn and food in calamitous years, numbers of which have existed all over Spain since the time of Philip II. M'Culloch, however, defines them to be merely public granaries where corn may be warehoused until it is disposed of. The name, which means "depositories," proves this definition to be the correct one. They have diminished in importance of late years, probably because the fears of occasional scarcity, which, no doubt gave rise to them, have been removed by the construction of roads and railways and a more liberal policy in respect of the corn laws. The peasants and dealers in grain in Castile formerly preserved their stocks in *silos*, or subterranean caves, for sometimes five or six years.

Mesta.

As has already been explained, *Mesta* was a right of common which certain privileged classes possessed, but which is now abolished. It is

said to have originated in the fourteenth century during a famine. This right enabled the privileged owners of large flocks of sheep to drive them over village pastures and commons there to feed at pleasure, and to compel the owners of cultivated lands, which lay in the line of their migrations, to leave wide paths for the pasturage of the flocks. Nor could any new enclosures be made in the line of their march, or land that had once been in pasture be cultivated again until it had been offered to the *Mesta*, or corporation of flock-proprietors, at a certain rate! It is easy to perceive that with the continuance of such monstrous privileges as these it would only be a question of time when all the cultivated lands would be turned into pastures, and all the pastures fall into the possession of the *Mesta*. It was a great reproach to Spain that this feudal privilege existed so long as it did, but its recent abolition is equally an undoubted sign of progress.

Number and Size of Farms.

The number of farms in Spain in the year 1800 was but 677,520 in the hands of 273,760 proprietors and 403,760 tenant farmers. (Martin.) The number of landed properties, rural and urban, in 1857, was 2,433,301 (L. T., 46), and the number in 1870 was 3,612,000. (*Ibid*, 19.) The proportion of rural properties in late years is not stated by these authorities, nor are the tenures by which they are held set forth. The number of tenant farmers had increased from 403,760 in 1800 to 595,635 in 1857, and probably upwards of 600,000 in 1870; but meanwhile and particularly since 1855 the number of properties had increased, both by the subdivision of land and the industrial absorption of mortmain and Government lands and village commons. The bulk of the peasant farms will average between ten and fifteen acres. There are many vineyards of not over one-eighth of an acre, and on the other hand, many large properties, cultivated and uncultivated. The opinion appears to prevail among late observers that from one-fourth to one-third of the cultivated land is held by peasant proprietors (L. T., 50 and ?), and that the rest is cultivated by agricultural laborers, of whom there were 2,354,110 in 1857, in the employ of large owners, or farmed out to tenants for a money rent, or *a la meta*.

System of Culture—Seeding and Fertilizers.

Compared with other countries west of Russia and the Orient, the system of culture in Spain is still very backward. There are a few garden spots in Spain—the *huertas* of Granada, Murcia, and Valencia—but such exceptional instances of careful culture are to be found in the worst cultivated countries, even miserable Egypt possessing a Faioum. The general aspect of Spanish agriculture, until very lately, was much the same as it was a century ago when Arthur Young visited Spain. The great and numerous barrens he described are being brought under cultivation, and in that respect Spain is much improved; but the mode of cultivation is only now undergoing change. The forests were, centuries ago, burned for the few fertilizing materials to be obtained from their ashes, while

their annual efforts to increase were kept down by a similar treatment of their undergrowth and copses. Hence, barrens, afflicted with alternate droughts and floods. The system of agricultural irrigation was mainly a legacy from the exiled Moors, since whose time it had been but little enlarged. The means used for raising the water are the familiar *sakye* and *shadouf* of the Orient, the *sakye* being known under the name of *noria*. (L. T., 57.) The water obtained by these laborious means is known as *agua de arte;* that by diverting the course of streams as *agua viva*, or running water. (C. R., 1868, p. 373.)

As going still further to show the indebtedness of even Modern Spain to Moorish industry, it has been stated that the best olive trees in Spain to-day are those left by the Moors; while even the stone fences and other enclosures left by them are still performing the service for which they were constructed a thousand years ago.

Rotation was, until recently, very little followed in Spain, and even the fallow system, though in general use, was in many parts ignored and the ruinous one of exploitation, by a constant succession of the same sort of crops, employed in its place. (C. R., 1871, p. 1037.) Even two and sometimes three different crops were obtained from the same piece of ground in one year; though as Young and other writers have shown, with no aggregate increase of product, but on the contrary, diminution. Corn, root, or pulse crops were frequently sown in olive groves and vineyards to the mutual detriment of both tree or vine and crop. In the Provinces of Malaga, Granada, Almeria and Jaen, mention is made of a three-field system of, 1. Wheat, barley or beans; 2. Fallow; 3. Pasture on the unirrigated lands; and also of the continuance, so late as November, 1869, of village commons (*dehesas de proprios*) for cattle,—both of them wretched and antiquated features of agriculture. But since 1855 all these features have been undergoing change, and the *dehesas de proprios* were probably in a moribund state in 1869.

The quantity of seed used is uncertain. It is stated by M'Culloch that the *fanega* (about 1½ bushels) is the measure of seed-corn commonly sown upon a *fanegada* (about 1½ acres) of land, and hence, the similarity of terms. This is probably a true explanation with regard to the terms, which must, however, have arisen from the results of favorable sowings; for the practical fact is still that not less than two bushels are generally sown to the acre of wheat, the staple corn of Spain.

In the use of fertilizers the same recent improvement is to be observed as in other respects. Previous to 1855, beyond the fertilizers mentioned by Arthur Young nearly three-fourths of a century before, there does not appear to have been any improvement. These consisted of wood-ashes obtained from the burning, not of forests, for they had been burned long before, but of copses and undergrowth. Near some of the large cities poudrette seems to have been prepared, but the use of this fertilizer was not common.

Since the ameliorations, which date about the year 1855, Peruvian

guano appears to have been largely imported into Spain. I have the statistics by quantities for only the years 1852 to 1856 and 1863 to 1867, inclusive; but these will serve to show the extent of the movement, which first began in 1852:

IMPORTS OF PERUVIAN GUANO INTO SPAIN.

YEARS.	KILOGRAMS.	TONS.
1852 to 1856, inclusive	49,115,446	48,247*
1863	39,514,969	39,209
1864	6,437,943	6,324
1865	11,956,769	11,746
1866	46,872,576	46,043
1867	37,666,000	37,000

To show the relation which these quantities bear to the world's consumption of guano, it may be stated that the 48,000 tons imported in 1852 to 1856 formed but 2½ per cent. of the world's consumption of Peruvian guano; while the average annual quantity of 28,000 tons imported during the years 1863 to 1867 formed 7½ per cent. of the world's consumption, which was 370,000 tons per annum during that interval. (For details of the consumption of each country, see Com. Rel., 1867, p. 361.)†

The extent to which fertilizers are now being used in at least some parts of Spain, may be judged from the fact that the U. S. Consul at Valencia reported in 1871 that the ground in that district was being burned up by an immoderate use of guano!

AGRICULTURAL IMPLEMENTS.

There seems to have been no improvement in respect of agricultural implements since the days of Arthur Young. The corvée is abolished and the absentee landlords of vast estates, of whom he has so bitterly complained, are things of the past; but the old Roman plow, with its wooden mould-board, without a bit of iron upon it (Arthur Young, ii, p. —), and its four or five inch blade (Com. Rel., 1871, p. 1037,) remain. Indeed, even the plow is rarely met with in some provinces (C. R., 1866. 219), the "laya," or two-pronged fork, and the spade being used in its place (L. T., 37 and 51).

Until within a very few years, agricultural machinery was wholly unknown in Spain. The corn was left in the fields for lack of barns (Young); it was threshed by driving mules over it; it was winnowed by throwing it in the air (M'Culloch); and most frequently it was ground by hand rather than by wind-mills or other machinery. (*Ibid.*)

* Quantities *exported* from Chincha Islands *to* Spain, 1852-57.—App. Cyc., viii, 529.

† The average annual consumption by the United States before the war is set down by this authority at 40,000 tons; while the actual imports into the United States from 1850 to 1861, inclusive, were 954,989 tons, an annual average of double the quantity. However, a portion of this guano came from other places beside Peru. For complete statistics on this subject, see U. S. Com and Nav., 1867, p. xlvi.

Fanning machines are now in use near the towns; the thresher has been introduced; and the first American mower and reaper was imported a year or two ago.

English implements are too heavy for Spanish hands (L. T., 29), and many that have been imported are left to rot for want of men able to handle them. The American implements are much preferred.

On the whole, it may be stated that Spain is but on the threshold of a change from the inefficient implements of antiquity to the powerful machines of modern agricultural progress.

Domestic Animals.

Since the destruction of her forests Spain must have lost much of the pastoral character which undoubtedly distinguished her to a great degree under the rule of the Moors. There are now, properly speaking, no meadows (grass lands) in Spain. Young noticed a single patch during his journey in 1787; but late observers do not speak of any at all. (L. T., 28, and elsewhere.)

Said M'Culloch, about forty years ago:

"The Pyrenees, the hilly parts of Biscay and the Asturias, the vast plains of Andalusia, the two Castiles, Estramadura and Leon, are almost wholly in pasture; and in some parts the traveler may journey for many miles without seeing either a house or an individual. In point of fact, however, half the pastures really consist of heaths, or of neglected tracts covered with thyme and other wild herbs, that are at present next to worthless. There are few or no irrigated meadows, and hay is seldom or never prepared for fodder."

Except that portions of this waste land have of late years been reclaimed, this description will answer for to-day.

The following table exhibits a comparison of the number of domestic animals in Spain in 1808 and 1865, respectively, from which it will be seen that there has been a small increase of horses, a considerable increase of mules and asses, a decrease of horned cattle, sheep and goats, and an increase of swine.

It should be stated that a great many incomplete and incorrect statements on this subject have appeared in statistical works.

The authorities for the figures given in the text are, for 1808, the report to the Cortes quoted by Macgregor, and for 1865 the report of Senores Feliciano Herreros de Téjada and Victoriano Ballaguer to the Statistical Congress of the Hague.

Domestic Animals.	Year 1808.	Year 1865.
Horses	533,926	680,373
Mules and asses	1,079,002	2,819,846
Horned cattle	3,694,156	2,967,303
Sheep and lambs	24,916,212	22,468,969
Pigs	3,628,283	4,351,736
Goats	6,916,890	4,531,228
Camels	No data.	3,104
Poultry	"	No data.

In some parts of Spain there are no inclosures (fences), and cattle cannot be kept without injury to the crops (L. T., 28). Of late years a new and considerable trade has sprung up between Spain and England, consisting of exports of horned cattle and of eggs from the former to the latter. The following table shows the development of this trade since 1860:

QUANTITIES OF ANIMAL PRODUCTS IMPORTED FROM SPAIN PROPER INTO THE UNITED KINGDOM ANNUALLY SINCE 1860.

Calendar Year.	*Horned Cattle. Number.*	*Eggs. Great Hund'ds*	*Calendar Year.*	*Horned Cattle. Number.*	*Eggs. Great Hund'ds*
1860.....	3,573	.....	1867.....	13,816	93.064
1861.....	8,596	123,842	1868.....	15,985	116,895
1862.....	6,787	139,628	1869.....	19,589	96,131
1863.....	6,566	78,818	1870.....	27,271	112,638
1864.....	8,281	54,465	1871.....	19,612	184,114
1865.....	8,209	31,328	1872.....	15,462	151,296
1866....	8,490	80.055	1873.....	19.888	151,564

CHIEF ARTICLES OF NATIONAL DIET.

The Spanish peasantry is even to-day but wretchedly fed; what it starved upon in the long and terrible ages of Ecclesiastical domination and feudal tyranny, defies all sober description. (On the general subject of peasant wretchedness in the Middle Ages, see *The Earth as Modified by Man*, by Marsh; New York, 1874, pp. 5–7, *the foot notes.*)

The usual fare is bread, porridge and pulse. Chestnuts and other mast also form articles of diet in the few wooded districts which the country possesses. (L. T., 24.)

The following accounts relate to the years 1869 and 1870: In Guipuzcoa, the nurture is beans, cabbages, milk, chestnuts, and Indian corn cakes in place of bread. Meat is scarcely known; occasionally a small piece of bacon is attainable. (L. T., 38.) In Biscay, the food is "puchero," a vegetable soup composed principally of cabbage and beans. Lard is occasionally added, and sometimes even a scrap of meat or dried codfish. (*Ibid*, 40.) The beverage in Asturias and Guipuzcoa is cider; in Biscay, it was "chacoli," a thin mixture of wine and water. Of late years this is becoming replaced by the common wine of Navarra, etc. In Majorca, the diet is vegetables and bread. (*Ibid*, 32.) In Minorca, it is potatoes. (*Ibid*, 35.) In Alicante, it consists of a pottage of rice, beans and oil, with barley or maize bread, and occasionally a little codfish or sardine; but butcher meat is seldom enjoyed. (*Ibid*, 51.) In Valencia, the usual food is, at morning, a pilchard (salted) and bread; at noon, a stew of beans and potatoes, with pieces of bacon; and at night, the same as at morning or noon. These articles of diet are usually supplemented with thin wine and sometimes fruit. (*Ibid*, p. 54, and private information.) In Galicia and Asturias, the food is potatoes and vegetable soup, condimented with lard; also bread of rye or maize; sometimes a piece of pork. (*Ibid*, 20.) In Andalusia, corn bread; seldom meat. (*Ibid*, 49.)

EFFECTIVENESS OF LABOR.

In Galicia and Asturias a good workman is expected to plow about one-fifth of an acre per diem. (L. T., 20.) One laborer only is required to every six acres yearly. (*Ibid*, 24.) One man with two horses or mules can plow in two days six *fanegadas* or 1.237 acres, equal to about five-eighths of an acre per day. (L. T., 53.) Consult also pp. 28 and 50 for similar, though less definite statements.

This extraordinary degree of inefficiency is not the result of indolence. All writers, from Arthur Young to the present time, agree in giving the Spanish peasantry the credit for untiring industry and perseverance. It is rather the product of weak and insufficient food and lack of comfort. (See Arthur Helps on Brassey.)

CONDITION OF THE PEASANTRY.

Galicia and Asturias, 1870. Their houses of rough stone—mostly consisting solely of the ground floor—are poor and dirty, the same roof frequently giving shelter to the proprietor's family and to the produce of his farm, including his oxen, cows, pigs and fowls. Some of the better conditioned of the same class construct with wood an upper story to their houses, which serves for their dwelling and granary, in which case the lower part is occupied entirely by the live stock. (L. T., 20.)

Majorca, 1870. Their houses are wanting in accommodations. Their food is frugal; their dress modest. (*Ibid*, 32.)

Minorca, 1870 Their cottages are of a cleanness that is remarkable, being whitewashed inside and outside twice a month. Their clothing, bedding, etc, are also very clean. Their habits are moral and religious. All disputes settled by arbitration. (*Ibid*, 32.)

Guipuzcoa, 1870. They are badly housed and have none of the comforts of the English. The kitchen is black, dirty and full of smoke They dress in home-spun flax. (*Ibid*, 38.)

Alicante, 1870. They are clothed in the linen shirt and short, wide trousers of their Moorish ancestors. (L. T., 51.)

Valencia, 1870. The peasants live in small stone or brick houses of one story, and in mud huts with thatched roofs. Their donkeys and pigs occupy a shed at the back of the house; but all pass through one door. (L. T., 53.)

Biscay, 1870. They are housed in stone buildings with no comfort and scarcely decency. Stables for oxen and pigs on the ground floor; sleeping apartment above. Results: dirt, discomfort and fever. Home-spun clothes, the men cloth, the women cotton and flannel from abroad. Habits thrifty. The tenant farms descend regularly from father to son by force of custom. (L. T., 41.)

Andalusia, 1870. The great mass of the country population are hired laborers. The Spanish peasantry are generally poorly housed, fed and clad. The country is still insecure, and abductions for ransom by

banditti are not unfrequent. (*Ibid*, 45.) The British Consul at Cadiz, under date of February 15, 1865, says :

"Property and life are much more secure throughout the country than they were twenty years ago. Robberies are very much more rare ; the police, and especially the rural police (*gens d'armes*) in the provinces, are in general respectable officials, and are becoming useful and effective. In numerous small towns (I speak of Andalusia especially) they are active, earnest and conscientious local magistrates, quietly doing a great deal of good." (B. C. R., 1865, 96.)

The travelers' guide-books of recent dates, which are pretty good authority on the subject of personal security, agree in stating that brigandage and all molestation on the highways have wholly ceased. This happy result is attributed indirectly to the general improvement of affairs in Spain, and directly to the *guardas civiles*, a body of police or *gens d'armes*, selected from the veteran corps in the armies, and composed of men noted for high moral traits and physical pre-eminence.

Concerning the tendency of thought among the peasants, it is stated that :

"Socialistic and communistic doctrines are spoken and spread in Andalusia where the peasantry, though very bigoted, are argumentative and of an independent turn of mind. If ever Protestantism, in some shape or other, be put before the Andalusian, it will spread like wildfire, for it exactly suits his mode of thought." (L. T., p. —.) Socialism is gaining ground among the laboring classes of Andalusia. (*Ibid*, p. 51.) "Spain has a peasantry superior to that of most European countries ; but no middle class."—*London Economist*, January 5, 1867.

The military conscription, which is compulsory in Spain, is perhaps, the most oppressive institution against which the peasant has now to struggle.

Illiteracy and Education.

The following table shows the condition of the population of all Spain in these respects in the year 1860 :

Classes.	*Males.*		*Females.*		*Total.*	
	Number.	*P. C.*	*Number.*	*P. C.*	*Number.*	*P. C.*
Able to read and write.	2,414,015	15.4	715,906	4.6	3,129,921	20.0
Able to read only.....	316,557	2.1	389,221	2.4	705,778	4.5
Not able to read or write	5,034,936	32.1	6,802,846	43.4	11,837,782	75.5
Total.....	7,765,508	49.6	7,907,973	50.4	15,673,481	100.0

Owing to the ecclesiastical policy popular education showed no perceptible progress in Spain until about the year 1868, since which time it has made considerable strides. (*A. G. Fuertes, U. S. Consul at Corunna, October* 1, 1873.)

In 1797 only 393,126 children attended the primary schools of Spain and these were very imperfect.

Up to 1808 public education was entirely in the hands of the ecclesiastics.

Until 1838 there was scarcely any progress.

In 1848 the number of pupils attending all the schools was 663,711.

On January 1, 1861, the number was 1,046,558, as follows: Private schools, superior, elementary and mixed, 3,800 with 134,383 scholars; public schools, same classes, 18,260, with 912,175 scholars.—*Martin.*

It is believed that since 1861 the number of pupils has fully doubled. For a summary of the extremely liberal provisions for public education since 1861, consult U. S. Rep. Com. Education, 1871, p. 477.

Wages.

Years 1787–89. (Arthur Young.) Wages near Esparagara, spinners, six cents a day; carders, eleven cents; lace-makers, nine cents and food. Near Gerona, laborers twenty cents, without food. Near Barcelona, laborers, twenty-five cents a day, without food; highest, thirty-three cents, lowest, twenty-two and a-half cents.

Year 1864. (Com. Rel., 1865.) Wages in Bilboa, day laborer, 20c.@25c.; mechanics, 40c.@45c., without food.

Year 1864. (Com. Rel., 1865.) Since 1854, a notable rise in wages in Bilboa: Day laborers now, 55c@70c.; mechanics, 95c.@$1.25 without food.

Years 1869 to 1871. (Land Tenures, pp. 20, 24, 32, 38, 40, 45, 51 and 53. Com. Rel., 1871, p, 1010.) The following table gives the wages current in various provinces of Spain:

Daily Wages of Agricultural Laborers, without Food, 1870–1.

Provinces.	Men.	Women.
Galicia and Asturias	24 @ 28 cents.	14 @ 20 cents.
Asturias	25 @ 35 "	.. @ 20 "
Majorca	20 @ 30 "	10 @ 15 "
Minorca	.. @ 24 "	.....
Guipuzcoa	.. @ 30 "	16 @ 20 "
Biscay	.. @ 40 "	20 @ 25 "
Andalusia	40 @ 50 "	.....
Ilicante	25 @ 30 "	10 @ 15 "
" spade work	40 @ 50 "	.....
Valencia	25 @ 35 "	.....
Murc'a	.. @ 28 "	.....
Spain generally *	30 @ 50 "	.....

* This last and probably unreliable line is from the C. R., 1871, p. 1010. The same authority quotes mechanics' wages throughout Spain at 40@75 cents per day, which is undoubtedly below the truth. It states the working hours in summer at fourteen, and in winter ten, which is probably correct.

DAILY AGRICULTURAL WAGES, WITH FOOD, 1870–1.

	MEN.	WOMEN.	BOYS.
Asturias	.. @ 12½	.. @ 07½	.....
Majorca	.. @ 10	.. @ 05	.....
Minorca	.. @ 15	.....	.....
" harvest, long hours	36 @ 45	.....	.....
Guipuzcoa *	12 @ 16	.....	05 @ 06
Biscay *	.. @ 20	.....	03 @ 04
Andalusia	.. @ 20	.....	.....
Murcia	.. @ 14	.....	.....

From these tables it would appear that in some places probably throughout Spain, wages continued, from the close of the last century to about the year 1855, without material change; but that since the last named date they have doubled. Whether this is due to the great ameliorations set on foot at that time in Spain, or to other causes cannot be determined in this place.

EMIGRATION.

During the years 1840 and 1841, at least 20,000 agricultural laborers left Valencia for Algiers. (*Macgregor*, 1015.) The immigration into the Argentine Republic (Buenos Ayres), which up to year 1862 was less than 7,000 persons a year, rose to between 10.000, and 12,000 persons in 1863 and 1864, and to over 40,000 persons in 1870. About 15 per cent. of of these persons in 1864 and 1870 were from Spain. (*Private information.*) There are now nearly forty agricultural colonies in the Republic. Of these, twenty have been formed since 1870. Many of the agriculturists are from Spain. The immigration of Spaniards into the United States, from 1820 up to and including 1870, was 23,504, and since 1870 has been as follows:

1871	558	1873	546
1872	595	1874, about	500

Large numbers of Spanish emigrants go to Cuba and South America, whence a few afterwards find their way to this country. In 1870, there were 3,764 natives of Spain residing in the United States.

I know of no statistics which show the total emigration outward from Spain, but it must be considerable. In Galicia and Asturias it is reckoned at 60,000 to 70,000 per annum, or 2½ per cent. of the population. (L. T., 20). One half of those from Asturias go to Spanish colonies. (*Ibid*, 24.) From Murcia 1,000 persons a month during six months of the summer and fall of 1869, went to Oran, coast of Africa. (*Ibid*, 28.) In the Balearic Isles emigration is not common, and the military conscription the principal cause. (*Ibid*, 32.) From Guipuzcoa there is a considerable emigration mainly to South America. The emigrants go chiefly by way of France. Cause, want of work. (*Ibid*, 38, 39.) From Biscay a large

* Guipuzcoa; boys $20@$30 a year, with food and lodging. Biscay, $15 a year, same.

emigration, which has been gradually increasing during the past fifteen years, occurs to South America, chiefly to Buenos Ayres and Montevideo. The local government has not been able to restrain this drain of population. (*Ibid*, 40.) From Andalusia emigration is rare, chiefly from Almeria and only in years of great drought. (*Ibid*, 45.) From Alicante, in years of drought the emigration to Africa is considerable. Many return when the weather (and, I suppose, their fortunes) improve. In good years they do not emigrate. (*Ibid*, 51.) The Valencians rarely emigrate. From the towns on the coast they frequently go over to Algiers and Oran for the harvest, and afterwards return home. (*Ibid*, 53.) The army and navy in the West Indies, and especially Cuba, constitute a regular drain upon the population by robbing it of its most energetic elements.

The American Cousul at Corunna, under date of September 30th, 1870, says that 140,000 emigrants have left that district (in Galicia), for South America and Cuba within a few years, and that 4,000 to 5,000 more bound to the same ports sail yearly from Corunna. "The agents at this port are always willing to offer them passage, to be paid in small installments. Repeated applications have been addressed to this Consulate regarding the emigration to the United States. The applicants are generally all handsome and remarkably healthy young men, used from their infancy to farming and field labor, as well as to mechanical pursuits and are withal of an excellent moral conduct and pleasant disposition, but as they are too poor to pay for their passage, I could offer no inducements to them." The same Consul writes in 1873, that he had induced a Liverpool shipping house to send some steamers to Corunna for the United States, and that they had arrived and taken out to New Orleans a large batch of respectable young field laborers.

Prices and Rents of Land.

It is almost impossible to make anything out of the fragmentary and loose evidence on this point contained in Arthur Young and *Land Tenures*, the best authorities for the latter half of the last and present centuries, respectively. Roughly speaking, arable land seems to be worth at the present time from $70 to $125 an acre, and in the *huertas* of Valencia as high as $500 to $1,000 an acre, the latter price being quite common. Rents range from 3 to 3½ per cent. on the value of the property (L. T., 41), and are stated to be on all the lands in Spain, including, I suppose, the barrens, from $2 to $4 an acre (L. T., 18), and on the irrigated *huertas* of Valencia, $20 to $35 (*Ibid*,) the common rate being about $30 an acre. (L. T., p. 54.)

These prices and rents do not appear to differ materially from those quoted by Arthur Young, nearly a century before. (See Young, ii, p. 326 and elsewhere.)

I take it that, at the rents quoted above, the tenants pay the taxes; yet as the following passage occurs in *Land Tenures*, p. 56, relating to Valencia, this point does not seem certain :

"The taxes on landed property are for account of the landlord, and *if the Government taxes the land, for a larger sum than it really* produces, then the landlord pays only to the extent of the rent and the surplus is paid by the tenant and is denominated as colonization." Spoliation were a better name.

TAXES.

Transfer and succession duties on land have already been adverted to. Although there is some discrepancy in the accounts, all agree in representing these dues as exceedingly onerous.

"The cost of registration is, in the first place, a Government transfer duty of 3 per cent. on the price in cases of sale or barter; 10 per cent. in cases of donation *inter vivos* (during life), and from 1 to 10 per cent. on successions, according to the nearer or remoter degree of relationship between the deceased proprietors and the heirs; inheritance from ascendant to descendant is free of duty, and on a lagacy to very distant relations or to mere friends, being strangers in blood, the duty is 10 per cent. The Registrar's fee varies according to the length of the deed inscribed, but it never exceeds 3 per mil (3 cents on $10) on the price or value of the property." (L. T., 44.)

Such heavy taxes and fees would seem to amount virtually, to a prohibition on the sale of land and must have very injurious effects upon agriculture.

The taxes levied in Spain are general, provincial and municipal. (Com Rel., 1856, p. 56.)

The municipal taxes consist partly of octroi duties. For example, in Bilboa and possibly all over the country, the octroi duties are: ale 2 cents per *pound*; brandy, 4 cents per *pound*; oil, 20 cents per arroba of 28 pounds; salt, 30 cents per fanega of 110 pounds, beside others. (Com. Rel., 1865, p. 190.) The Galicians are taxed on almost everything they possess in the way of property: land, labor, food and raiment. (Com. Rel., 1871, p. 1008.)

Similar charges are exacted in Cadiz and on foreign products which have paid duty as well as on domestic. (Com. Rel., 1866, p. 222.)

Heavy taxes are also spoken of in Valencia. (L. T., 54, § 13.)

The General Government levies export duties (Com. Rel., 1873, p.; 961) also import duties, direct taxes on land, mines, industries, commerce, mortgages, excise, tolls, stamps, railway passengers, and miscellaneous. It derives revenues from the following monopolies: tobacco, salt, gunpowder, lotteries, mints, military establishments, post office and miscellaneous, and from the following domains: mines, property of the State, clergy and provinces, besides a revenue from the colonies. The total annual revenues of the General Government during the period 1865–70 were estimated in the budgets at between $107,000,000 and $138,000,000 per annum. This would amount to an average of about $7 per capita of population.

If the provincial and local taxes be added to these, the total bur-

den of taxation would be exceedingly onerous — especially when the industrial condition and efficiency of the country, as compared with other countries at the same period, is taken into consideration.

"The direct tax on real property, on agricultural produce and on cattle, has, during the last twenty years, nearly doubled, throughout the whole of Spain.

1846 to 1848,	it amounted	to	$12,500,000.
1849 to 1855,	"	"	15,000,000.
1856 to 1857,	"	"	17,500,000.
1858 to 1863,	"	"	20,000,000.
1864 to 1866,	"	"	21,500,000.

The same tax levied by the local authorities throughout Spain, for provincial and municipal purposes, has risen, during the same period, from $1,750,000 to $4,434,585." (Br. Con. Rep. 1866–5, p. 375.)

Interest.

In the year 1545, Charles the Fifth fixed the legal rate of interest in Spain and the Low Countries at 12 per cent. (*N. Y. Social Science Review*, 1865, pp. 362–3.) From that time until toward the close of the last century, the market rate of interest in Spain continued to fall, not so much from increased profits or security as from an increasing absence of opportunities for the investment of capital. This is proved by the fact that while generally the market rate of interest fell, the rate on Government securities rose.

At the time of Arthur Young's travels the market rate on landed security in Catalonia was 8 to 10 per cent.

Since that time the usury laws have been entirely abolished, and now interest is left free to be determined by the contracting parties. (L. T., 24.)

The prevailing rates on landed security about the year 1870 were from 4 to 5 per cent. per annum in Biscay and the Balearic Isles, the two extremities of Spain (L. T., 31, 37, 40), to 10 or 12 per cent. in Murcia. (*Ibid*, 28.) In the rest of the provinces, and Spain generally, it appears to be from 6 to 10 per cent. (*Ibid*, 18, 20, 24, 44, 50, 53.)

On the security of growing crops, or personal security the rates are most frequently 30 to 40 per cent., though of course they vary with the degree of risk in each case. (*Ibid*, 18, 24, 44.)

According to the quotations of the Madrid Bourse, at the close of the year 1874, Government securities were at prices that yielded interest at the rate of from 12 to 20 per cent. per annum.

Code of Law—Credit—Debt—Executions.

"The habits, customs, laws, have accumulated from the earliest ages, —Gothic, Christian, Jewish and Moorish,—forming an inextricable web which no legislator has attempted to unravel. Codification has been often talked of, and even attempted, and as yet produced nothing. The consequence is that most Spanish proprietors are perpetually involved in law

suits, which are lost and won, and lost again, going from one province to another and appealing to different courts and tribunals, one after the other." *H. B. M. Sec. of Leg. Percy Ffrench, Madrid, December* 7, 1870. (L. T., 19.)

For organization of courts of law and proceedings on judgments and evictions, see L. T., 26.

There are no special courts of bankruptcy. (*Ibid.*) "No questions are submitted to jury." (*Ibid.*)

Agricultural banks on the German plan have been tried but failed. (L. T., 55.) The system of legal procedure against debtors is the great drawback to credit based upon land. Even lending money upon mortgage is dangerous. (L. T., 44 and 47.) In many places money on land is only to be had on a sale *á retro*, or *á remoré* (L. T., 47), which seems to be a sale with power of redemption.

The laws give the landlord to whom rent or allowances for deteriora tions are due, a preference over other creditors to the extent of the cattle, household effects and other moveables found upon the property (L. T., 26, 34, 38 and 48); but not the mules, horses, plows, or carts; which appear to be exempt from execution. (*Ibid*, 51.)

A custom is said to exist in Valencia which is peculiar, and as it may be common elsewhere in Spain, and has a bearing on the tenure of land and security, credit and interest, I insert an account of it here:

"When an eviction occurs (generally a rare thing in the agricultural parts of Spain), if the landlord does not pay the colonist or tenant the value of the buildings (erected by the latter), the tenant pulls them down and carries away the materials; this, however, rarely happens." (L. T., 56.)

COMMON ROADS.

"Owing to the badness of the roads and their unfitness for carriages, the principal carriers of merchandise are the *arieros*, or muleteers, who traverse the country in all directions along beaten tracks, many of which are accessible only to them. * * * Three-fourths of the entire inland traffic in corn is carried on by their means. Recently, however, wagons have begun to be introduced." (M'Culloch, 11, 839.)

This was the condition of affairs described in 1844.

Under date of July 1, 1865, the British Secretary of Legation, at Madrid, wrote as follows:

"Even the few main roads (common roads) which exist, are insufficiently provided with bridges, and it is not an uncommon sight to see eighty or ninety "carros" or country carts laden with agricultural produce, detained on the banks of a flooded river until able to ford, sometimes for three or four days. * * * Fifty years ago the internal communication was entirely carried on by means of mules, and few, if any roads existed." (*Br. Rep. Sec. Leg.* 1866, *p.* 184.)

COMMON ROADS IN 1860.

	KILOMETRES.	MILES.
First class	9,097	5,640
Second "	1,550	961
Third "	629	390
Total	11,276	6,991

"Also in course of construction 4,276 kilometres or 2,651 miles. Amount expended on roads in 1861 and 1862, $14,735,829." (*Ibid.*)

Since the conclusion of the civil war, the Government has constructed upwards of 10,000 miles of turnpike roads, exclusive of Biscay, where the roads have been built by the local authorities. (Br. Con. Rep. 1865, p. 83.)

A better view of the progress that has taken place is afforded by the following:

TABLE SHOWING THE LENGTH AND CONDITION OF THE VARIOUS CLASSES OF COMMON ROADS IN SPAIN IN THE YEAR 1867.

CLASSES.	KILOMETRES.	MILES.
First class roads	7,339	4,550
Second " "	9,566	5,931
Third " "	17,766	11,015
County "	4,540	2,815
Total	39,212	24,311

Of the above roads 12,342 miles were built, 2,087 miles in course of construction, and 9,882 miles projected in 1867. (Br. Stat. F. C. xii, 292.)

CANALS AND SLACK-WATER NAVIGATION.

Since the destruction of the Spanish forests, such of the rivers of Spain as were navigable before, were rendered unnavigable. Of these only the Tagus and Guadalquiver had been rendered partly navigable up to the year 1844. (M'Culloch.)

In 1871, owing to recent improvements in the river channel, vessels drawing from 16 to 18 feet of water could ascend the Guadalquiver to Seville. (C. R. 71, 1028.)

I have no other advices with respect to the progress of slack-water navigation in Spain. Of the canals of Spain, glowing accounts in general terms are to be found in many descriptions of the country (*e.g.* Appleton's Cyc., xiv, 805, Old Ed.), but I cannot find sufficient basis for them. There appear to be but three canals of any importance in Spain, and the aggregate mileage of the three is not over 300. These are 1. The Ebro Canal, in Arragon, from Tudela to Santiago, 41 miles below Saragossa. It was built in the reigns of Charles III, IV and V, is about 85 miles long and is navigable by barges, and used also for irrigating purposes. 2. The canal in Old Castile from Segovia, past Valladolid and Palencia, to Aguilar del Campo, and thence to the Bay of Biscay, with a way branch

to Rio Seco and another to Bourgos; commenced in the year 1753. 3. The Urgel Canal in the Gerona district of Catalonia. These canals are also navigable for barges. I do not find any other navigable canals of importance, and to say that the aggregate navigable canals of Spain are less than 500 miles in length would probably be largely within the truth.

Railways.

The following is a tolerably complete list of all the railways in Spain at the close of the year 1872, omitting branches and turn-outs:

Railways.	Miles Opened.
* Madrid to Saragossa and Madrid to Alicante	885
* Saragossa, Pamplona and Barcelona	385
* Barcelona to France *via* Figueras	109
* Northwestern Railway, Palencia and Corunna, Palencia and Leon *via* Gijon	158
* Medina del Campo to Zamora and Orense to Vigo (Medina to Zamora finished; Zamora to Orense not begun; Orense to Vigo unfinished)	56
* Cordova to Seville	81
Seville to Cadiz about	80
Branch to Moron about	20
* Cordova to Malaga Branch to Antequera Branch Loja to Granada	184
* Lerrida to Reus and Tarragona	50
* Aranjuez to Cuenca, 80 miles unfinished	....
* Aranjuez to Toledo	25
* Santiago, 27 miles unfinished	....
* Urgel Canal Railway	33
* East Coast Railway, Almansa † to Valencia and Tarragona	255
Tarragona to Barcelona	80
Madrid to Avela 40 miles, Avela to Medina del Campo 50 miles, Medina to Palencia 50 miles, about	140
Cordova to Alcazar (on Madrid and Alicante Railway), about	100
Badajos to Manzanares (on last named Railway), (this line connects with Lisbon, Portugal), about	250
Palencia to Burgos and Miranda, about	100
Bilboa, Miranda and Saragossa, about	150
Palencia and Santander, about	100
Barcelona and Gerona, about	60
Granollers to Junction with last named Railway, about	25
Barcelona and Reus, about	80
Miranda, Vitoria, Pamplona and Alfara, about	100
San Sebastian to Fuentarabia, about	20
San Sebastian, Guipuzcoa and Alsasua, about	50
Cartagena, Murcia and Chinchilla, about	150
Cordova to Belmez	45
Total miles opened	3,771

* Subsidized by Government.

† *I.e.*, from near Almansa on the Madrid and Alicante Railway.

The first railway, 15½ miles in length, was opened in 1848 from Barcelona to Mataro on the line now completed from Barcelona to Gerona. The following table shows the progress made from time to time since that year:

Close of the Year.	Miles Opened.	Close of the Year.	Miles Opened.
1848	15½	1862	1,694
1850	17	1863	2,208
1856	326	1864	2,525
1857	418	1865	2,982
1858	529	1866	3,184
1859	713¼	1870	3,380
1860	1,191	1872	3,711
1861	1,475	1874	4,100

From this table it will be observed that from 1848 to 1860, inclusive, a period of thirteen years, hardly 1,100 miles of railway were constructed in Spain; while from 1860 to 1874, inclusive, a period of fifteen years, nearly 3,000 miles were opened.

The area of Spain proper is 190,257 square miles, and of California 183,981 square miles. At the close of the year 1873 there were 1,368 miles of railway constructed in California; so that Spain with about the same area had nearly three times the railway mileage of California.

Beside the above there are many other roads in course of construction; for example: One from Seville to Lisbon *via* Merida and Badajos, the distance from Seville to Badajos, which is on the Portuguese border, being some 150 miles. (C. R., 1871, 1029.) One from Cordova to Belmez, 45 miles. (*Ibid.*) Opened in 1873. (C. R., 1873, 959.)

Concerning the roads which form the line between Madrid and the French frontier, the American Counsel at Bilboa, wrote in 1864 to the U. S. State Department, as follows:

"The Great Northern Railway, *Linea del Norte*, was opened (asa through line) on the 20th of August, 1864, for passengers and merchandise, from Madrid to Irun, on the French Frontier, where it connects with the railway to Paris. The line has been operated through Castile and other sections, for a considerable period; but the heavy character of the work—the engineering difficulties of carrying the line over and under the Pyrenees, which here break up into detached spurs—has long delayed the enterprise, lately so happily completed. The largest tunnel—in Guipuzcoa—is 2970 yards in length, and is 1869 feet above the sea-level. Besides this, there are 22 other tunnels, measuring in all, six miles. The Viaduct of Orinostiqui is 1120 feet long, and is carried over five arches, each having a span of 150 feet.

The construction of this road is a grand tribute to engineering skill, and will place Madrid within 35 hours of Paris." (Com. Rel., 1864, 279.)

HARVESTS IN SPAIN—RECENT YEARS.

1865. Grain abundant. (U. S. Com. Rel., 1866, 215.) One-third above average. (*Ibid*, 219.) Largest for many years. (*Ibid*, 1865, 175.)

1866. Grain hardly average. Potatoes deficient. (U. S. Com. Rel., 1867, 343.) Grain one-third less than in 1865. (Br. Con. Rep., 1867, 88.) Drought in Alicante. (*Ibid*, 1867–4, 133.)

1867. Grain moderately good. (Br. Con. Rep., 1868–7, 521.) Olives failed (*Ibid*, 1867–3, 87.) Also silk; this being the fifth year of failure. (*Ibid.*)

1868. Grain deficient. (Br. Con. Rep., 1867–8, 521.)

1869. Grain barely average. (U. S. Com. Rel., 1871, 1008.)

1870. Grain harvest good.

1871. Lemon crop in Andalusia the largest ever obtained. (U. S. Com. Rel., 1871, 1022.)

1872. Grain crops fair. (U. S. Com. Rel., 1872, 777.)

1873. Grain crops excellent. (U. S. Com. Rel., 1873, 938.)

1874. Grain crops good.

It is said that when the harvests are good in one section, the north or south of Spain, they are bad in the other; (Br. C. R., 1868–7, 521); but this statement must be taken with considerable allowance for error.

VARIETY OF AGRICULTURAL PRODUCTS.

The agricultural products of Spain are almost endless in their variety. The principal ones are as follows:

Grain Crops.—Wheat, maize, barley, rye, buckwheat, millet, oats, rice.

Green Crops.—Clover, grass, kitchen vegetables.

Root Crops.—Sweet and Irish potatoes, cassava, (*moniato* or *convolvolus batatas*,) raised in the Balearic Isles, and much used by the peasants for food; (L. T.,) liquorice; *catufas de Valencia;* peanuts.

Leguminous Crops.—Beans: 1 French beans; 2 string beans; 3 garbanzos; 4 carob-beans (the *algarobo* or *locust bean*, used as cattle fodder).

Fruits.—Apples, peaches, apricots, nectarines, pears, plums, cherries, grapes, oranges, lemons, limes, pomegranates, figs, olives, melons, berries, prickly pears.

Commercial Crops.—Sugar cane, cotton, esparto grass, hemp, flax, saffron, madder, red pepper, capers.

Nuts and Forest Products.—Chestnuts, walnuts, almonds, hazel-nuts, cork, oak and pine bark, acorns.

Animal Products.—Silk, wool, cheese, leather, eggs.

Liquids.—Wine, spirits, ale, cider, oil.

The grain crops will be more particularly mentioned hereafter. Of the other crops, those which demand attention on account of their importance, are oranges and lemons, figs, olives, esparto grass, almonds, cork, silk, wine and olive oil. Some idea of the production of these articles in Spain may be gathered from the list of exports hereinafter given, after due allowance is made for the quantities consumed in the country of their production.

PRICES.

The average of the prices of grain and meat in all the 49 departments of Spain in the month of July, 1874, is shown in the following table from the *Gaceta de Madrid:*

Average Prices in all the Provinces of Spain, July, 1874.

Wheat, (*Trigo*)	per bushel,	$1.57½
Barley, (*Cebada*)	"	.94
Rye, (*Centeno*)	"	1 00
Maize, (*Maiz*)	"	1.14
Rice, (*Arroz*)	per pound,	.05½
Large Chick Peas, (*Garbanzos*)	"	.06
Mutton, (*Carnero*)	"	.10
Beef, (*Vaca*)	"	.11½
Bacon, (*Tocino*)	"	.16½

Maximum and Minimum Prices in Various Provinces.

Wheat, *maximum*	per bushel,	$2.73
" minimum	"	.91½
Barley, *maximum*	"	1.49
" minimum	"	.50

It is not explained how these prices are determined, nor whether they are wholesale or retail; but I take it they are determined by public sales at market towns and at wholesale. The difference in prices in the various provinces, ranging from 91½c. to $2.73 per bushel for wheat, and 50c. to $1.49 per bushel for barley, show that, notwithstanding numerous railways, there still exist in Spain obstacles to the mobilization of breadstuffs which should demand the serious attention of the Government. It can hardly be due merely to the cost of transportation by railway that wheat and barley are three times as high in one province as another, and the tables published every month in the *Gaceta* show this to be the case, more or less, throughout many years. Spain is an extensive country, and as yet comparatively destitute of water-ways and other cheap modes of carriage. Still, 500 miles by rail will carry a bushel of wheat from one end of the country to the other, and unless the extreme prices quoted are in places as yet remote from the established railway lines, or octroi duties hinder the free circulation of commodities, I am at a loss to account for the disparities shown in the prices of the principal edibles.

COMMERCIAL POLICY—CORN LAWS—TARIFFS, ETC.

The severe restrictions which formerly characterized the Spanish commercial policy have been much modified of late years.

Until 1865 the *exportation* of breadstuffs, with occasional exceptions at long intervals, was prohibited, except to the colonies. (U. S. Com. Rel., 1866, p. 215.) I find, however, that in 1860, 1861 and 1862 there were, comparatively speaking, considerable exports of grain and flour from Spain to England, and I infer from this that the harvests of

those years were unusually abundant in the former country. Although the prohibition to export breadstuffs appears to have been removed in 1865, there only appear to have been considerable exports of those articles, since that date, in 1866, 1867, 1872, 1873 and 1874.

The principal features of the regulations with regard to the *importation* of breadstuffs appear to have been as follows:

1849. Act of July 17 prohibited imports of breadstuffs except at periods of scarcity. (Com. Rel., 1862, 220.)

1856. Grain crop deficient. Decree of May 13, 1857, admitted breadstuffs free until December 31, 1857. Decree of September 16, 1857, extended the time until June 30, 1858. Breadstuffs imported from France, Morrocco, Egypt, England and the Baltic. (Com. Rel., 1858, pp. 99–100.)

1863. January 1, new tariff. Metrical system introduced at custom houses. Octroi duties abolished and tariff increased on principal "tropical" imports, such as tea, coffee, etc. Tariff schedule simplified, but rates not lowered; on contrary, raised. Importation of breadstuffs still prohibited. (Com. Rel., 1863, 217.)

1865. April 1, regulations regarding imports of flour into colonies. June 28, other regulations, to wit: heavy discriminating duties on foreign flour into colonies. For example, duty on American flour into Cuba $9.50 per bbl.; on Spanish, $2.25. (Com. Rel., 1865, 176.)

1867. Duties on agricultural implements reduced to one per cent. in Spanish and one and one-fifth per cent. in foreign vessels. (*U. S. Monthly Statistics, November*, 1867.)

1867. July 1, importation of grain still prohibited. (Br. Con. Rep., 1867, 228.)

1867. August 22, decree admitting breadstuffs as dutiable articles for four months. October 25, time extended to June 30, 1868.

1868. January 11th and 17th, wheat and other alimentary substances admitted *free*. April 22, free entry of above articles extended to December 31, 1868.

1869. July 12, new tariff in force from August 1. Duties reduced on certain classes of articles about five per cent. Premium of $3.50 per 100 kilogrammes on exports of sugar refined in Spain. *Discriminating duties abolished.* Duties on agricultural implements one per cent. *ad valorem.* Duties per 100 kilos on rice, cleaned, $1.60; oats, 52c.; barley and maize, 45c.; wheat, 60c.; and peas, beans, etc., 60c. On flour 50 per cent. in addition to the grain of which it is made. (For full schedule, see *U. S. Monthly Statistics, July*, 1869.)

1873. Breadstuffs still permitted to be imported.

1874. " " " " "

Commerce.

As increase of commerce is far from being a necessary indication of increase of wealth, I do not offer as evidence of progress in Spain the increase which has lately taken place in her commerce, both foreign and domestic. But as I wish to show the character of her foreign commerce, particularly the exports, and still more particularly the exports of agricultural produce, I herewith append a complete table of the exports of 1872, and such other statistics on the subject as will tend to show the nature and extent of the agricultural and mineral products of Spain.

Table Showing the Quantities of the Principal Articles Entered for Exportation at the Custom-Houses of Spain (including the Balearic Isles) during the Calendar Year 1872.

Principal Articles,	*Quantities.*	*Principal Articles.*	*Quantities.*
Olive oil, pounds	42,187,595	Wheat flour, lbs	10',379,672
Spirits (aguardiente), gallons	1,552,367	Soap, lbs	10,460,624
Preserved food, pounds	4,673,055	Wool, raw, lbs	9,708,472
Corks: manufactured, M	1,015,312	Legumes: carob beans, lbs	16,881,755
in slabs, lbs	3,212,532	garbanzos, lbs	7,576 205
in pieces, lbs	1,248,643	beans, lbs	646,672
Esparto: crude, lbs	104,789,203	French beans, lbs	1,338,113
manufactured, lbs	6,201,923	Metals: quicksilver, lbs	4,180,946
Spices: anise, lbs	1,379,697	copper, ingots, lbs	780,960
saffron, lbs	174,900	iron, lbs	12,476,053
cumin, lbs	458,858	lead, lbs	207,701,747
pepper, ground, lbs	846,270	Ores: zinc, lbs	73,596,800
Dry Fruits: almonds, lbs	8,229,437	copper, lbs	584,987,900
hazel-nuts, lbs	12,257,696	iron, lbs	1,578,831,800
peanuts, lbs	4,278,446	other, lbs	105,015,984
raisins, lbs	110,471,456	Paper, lbs	4,304,582
all other, lbs	10,190,715	Soup pastry (maccaroni,	
Fresh Fruits: lemons, lbs	15,847,236	etc.), lbs	5,139,497
oranges, M	547,400	Licorice: root, lbs	13,719.741
grapes, lbs	9,620,080	extract and paste, lbs	1,604.931
all other, lbs	2,485,767	Salt, lbs	328,908,136
Cattle, number	246,946	Silk, raw, lbs	309,661
Grain: Canary seed, lbs	977,051	Wines: white, gal's	1,250,200
rice, lbs	10,934,605	common, gal's	24 564,700
oats, lbs	3,472,341	do. of Catalonia, gal's	2,645,400
barley, lbs	11,862,480	sherry and port, gal's	9,120,400
rye, lbs	6,394,923	Malaga, gal's	567,000
wheat, lbs	113,809,762	other sweet, gal's	43,000

The most valuable articles of export at the present time are, 1. Wines; 2. Metals and ores; 3. Fruits; 4. Breadstuffs: 5. Oil; 6. Cork; 7. Cattle; 8. Salt; 9. Wool; 10. Esparto; 11. Silk; and 12. Spirits; and generally in the order named.

Wines.—The export of wine consists chiefly of sherries, which had usually amounted to some 8,000,000 or 10,000,000 gallons per annum, but in 1873 rose to 15,000,000 gallons, and of common red wines, which had usually amounted to some 25,000,000 gallons per annum, but in 1873 rose to 40,000,000 gallons. The following remarks on these two classes of wine will doubtless be read with interest:

About one-fifth of the entire shipments of so-called sherry wine from the Cadiz district consists of low and spurious compounds mixed in Spain, and worth in Cadiz from $50 to $100 per butt of 30 arrobas, say, net, 100 gallons. About two-fifths consist of ordinary sherry, worth from

$125 to $225 per butt. About three-tenths consist of good sherry, worth from $225 to $350 per butt. The balance, one-tenth, consists of superior sherry, worth from $350 to $1,000 per butt.

The best wines come from the district between Port St. Mary and Jerez, the low grades from other parts of Spain. The grapes are pressed with the feet, cased in sandals of esparto grass, and the wine has an earthy, tarry flavor, which is only removed from it after doctoring. The spurious compounds contain some of this wine, to which are added German potato-spirits, water, molasses, litharge and other adulterations. It is these two last grades of wine that the British chiefly sell and Americans buy. Indeed we buy from the British if even we buy in Cadiz; for there a large portion of the houses engaged in the trade are English. The wines are entered at our custom-houses as containing less than 22 per cent. of alcohol; while they really often contain 40 per cent.

There are four substances generally used in the manufacture of sherry. First, gypsum; second, a coloring substance; third, a sweetening substance; fourth, a spirituous substance. It has already been stated how these adjuncts are supplied to the low grade sherries; it only remains to state what substitutes for those mentioned are used in the preparation of the medium grades.

First, gypsum; second, color-wine, or wine boiled down to the consistency of sugar-house syrup; third, sweet wine, or wine made from raisins; fourth, brandy. Wine made in this manner is tolerably palatable. Most of the "crack" dry sherries belong to this class. They are entered at our custom-houses as containing not over 22 per cent. of alcohol. They really contain from 32 to 36 per cent.

The only really pure sherry wine is Amontillado, but as every sort of trash is called Amontillado, it is difficult for any one but an expert to distinguish the genuine article from the spurious. However, it is pretty safe to say that little or none of it comes to the United States.

Amontillado is not always the product of design. The quantity made in Spain is quite small, and the wine often the result of accident. To make this wine, the fruit is gathered some weeks earlier than for other sherries. The grapes are trodden by peasants with wooden sabots on their feet. The wine is then allowed to ferment for two months or more, when it is racked and placed in depositories above ground. Of a hundred butts but two or three may turn out Amontillado. This Amontillado is neither the product of particular vineyards, nor always the result of a careful or special mode of treatment, but the unaccountable offspring of several modes of treatment before, during and after fermentation. Fair Amontillado (by no means the best) is worth in Cadiz $1.50 to $2 a bottle. It probably cannot be purchased in the United States at any price. There is not a drop of spirits added to it, and no sherry wine containing foreign alcohol can be Amontillado.

I am assured by the Spanish Consul at Philadelphia that a very con-

siderable proportion of the so-called French claret wines, mostly the lower grades, are compounds, made of Spanish wines, imported chiefly at Cette. These wines are mixed with water, cheap spirits, a purple-coloring matter, and some other substances. They are then bottled, labeled with high sounding names and exported to all parts of the world as Bordeaux wines. In many cases the adulteration is carried so far that there is scarcely a trace of wine in the mixture, and what there is of it is the common *vino tinto* of Spain, worth about 22 to 23 cents a *gallon* in that country. (The total value of the 37,262,126 gallons of this class of wine exported from Spain in 1873 was $8,467,785.)

The following table shows the quantities of wines exported from the Peninsula of Spain and the Balearic Isles during the years 1872 and 1873:

Exportations of Domestic Wines from Spain in the Calendar Years 1872 *and* 1873, *respectively.*

Class of Wines.	1872. Gallons.	1873. Gallons.
White wines	1,250,153	1,409,110
Common wines	24,564,686	37,262,126
Ditto of Catalonia	2,645,432	2,713,083
Jerez (sherry) wines	9,120,389	14,840,609
Malaga wines	566,504	315,998
Rich wines (generosos) from various parts	43,001	120,518
Total	38,190,165	56,661,444

Breadstuffs.—This trade has increased enormously. Since the prohibition to export breadstuffs was removed in 1865, the shipments from Spain have increased over *four* times, or from about 5,250,000 bushels of wheat and flour to about 23,000,000 bushels.

Table Showing the Exports of Wheat and Wheat Flour from Spain:

Year.	Flour. Pounds	Wheat. Pounds.	Total. Pounds.	Year.	Flour. Pounds.	Wheat. Pounds.	Total. Pounds.
1860	96,800,000	No data.	96,800,000	1867	110,074,800	95,256,000	205 330,800
1861	160,600,000	"	160,600,000	1868	43,434,600	5,040,000	48.474,600
1862	94,600,000	"	94,600.000	1869	No data.	No data.	No data.
1863	84,620,800	4,043,040	88,663,840	1870	"	"	"
1864	78,234,200	2,430,300	80,664,500	1871	"	"	"
1865	87,687,600	35,940,000	123,627,600	1872	223,036,000	250,382,000	473,418,000
1866	167,312,200	147,336,000	314,648,200	1873	441,540,000	931,480,000	1,3730,20,000

The exports of breadstuffs other than wheat or flour are unimportant. The following tables gives the details for the year 1872 and 1873:

TABLE, SHOWING THE EXPORTS OF VARIOUS GRAINS AND LEGUMES FROM SPAIN, IN THE YEARS 1872 AND 1873, RESPECTIVELY:

BREADSTUFFS.	1872. POUNDS.	1873. POUNDS.
Rice	10,934,605	10,441,506
Oats	3,472,341	6,174,870
Barley	11,862,479	6,389,007
Rye	6,394,923	4,033,663
Soup pastes	5,139,497	4 723,532
Carob beans	16,881,755	8,783,780
Garbanzos (large chick peas)	7,576.205	7,885,100
Beans	646,676	1,255,465
French or Kidney beans	1,338,113	1,571,123
Total	64,246,594	51,258,046

The imports into Spain consist at the present time chiefly of tropical products and northern manufactures. Breadstuffs, chiefly wheat and maize, are only imported in years of scarcity. The following are the imports of breadstuffs in the year 1872 and 1873, respectively :

BREADSTUFFS.	1872. POUNDS.	1873. POUNDS.
Wheat	62,473,622	154,000
Other grain	17,062,228	4,509,690
Flour	16,179,207	153,000

MINING.

The revival of mining in Spain dates from the decree of Ferdinand VII., of July 4, 1825. (Br. C. R., 1868–5, 299.) That this judgment must be well based is very evident from the degree of progress shown in the following tables. The statement for 1780 is from Hoppensack, quoted by Macgregor. Those for late years are from the Br. Con. Rep., 1867–8, 560, the U. S. Monthly Stat., Mar., 1870, and U. S. Com. Rel., 1873, 964.

Table showing the number of metrical tons of (2,200 *pounds each*) *of Ore raised in Spain during the years named.*

Year.	Iron.	Lead.	Argentiferous Lead.	Silver.	Copper.
1780	9,000	1,600	.....	.....	15
1860	175,503	320,603	.....	4,230	224.152
1861	130,259	361,164	.....	3,005	246,611
1862	213,192	281,202	.....	2,523	313,913
1863	212.676	313,851	.....	3,060	343 131
1864	253,120	274,589	25,111	1,818	213.389
1865	191,684	271,318	19,323	1,125	273,184
1866	180,131	267,494	21,312	1,704	279,527
1870	436,586	318,985	33,248	2,679	395,695

Year.	Tin.	Zinc.	Cinnabar Mercury.	Phosphorus.	Antimony.	Manganese.
1780	....	125	900	.....	300	.....
1860	....	108,802	21,662	.....	....	28,863
1861	...	24,743	18,254	.....	....	14,071
1862	....	41,104	27,441	.....	....	6,459
1863	....	48,124	26,304	.....	....	14,860
1864	63	80,222	19,800	.....	74	22,246
1865	93	70,158	16,425	12,800	29	24,864
1866	30	73,423	18,547	9,304	..	39,624
1870	28	113,583	23,744	27,978	80	16,823

Year.	Alkali.	Alum.	Sulphur.	Coal.	Lignite.	Asphaltum
1780	.....	.....	.....	(1858, 170,000)	.....	....
1860	17,557	.....	23,045	321,773	17,523	....
1861	11,691	.....	23,148	331 055	22,292	....
1862	5.022	.....	12,639	360.246	28,696	....
1863	8,090	.....	11,982	401,301	50,302	....
1864	11,822	8,179	9,788	387,904	38,529	3,825
1865	7.667	9 044	10,708	461,396	34,455	795
1866	9,912	7,588	16,242	393,105	39,559	2,663
1870	7.975	13,250	15,156	621,847	40,095	478

The number of metrical tons of Salt produced in the Government Salt Mine was as follows:

Year.	Met. tons.	Year.	Met. tons.
1860	391,692	1863	187,271
1861	201,775	1869	170,000
1862	182,208	1870	37,917

The number of producing Mines of all kinds throughout Spain and the laborers and steam engines employed therein are as follows:

Year.	Number of mines.	Number of laborers.	Number of steam engines.
1860	1,988	33,297	39
1861	1,795	33,603	51
1862	1,386	36,635	52
1863	1,594	35,801	64
1864	1,842	37,201	76
1865	1,912	37,515	80
1866	2,283	38,483	94
1870	3,381	* 41.010	148

It needs but a cursory glance at these tables to perceive that of late years Spain has made great progress in this important branch of her national industries. Details of the smelting and refining establishments for iron and steel, lead, silver, copper, etc., none of which nor their products, have been included in the above tables, will be found in the

* To wit: men, 33,277; women, 1,508; boys, 6,225.

U. S. Com. Rel, for 1873. For account of power-looms, see Br. Con. Rep., 1867–8, 550; of fisheries, U. S. M. S., Mar., 1870; of manufactories in Catalonia, U. S. Com. Rel., 1862, 208; and 1864, 262.

PRODUCT OF BREADSTUFFS.

The accounts of this product which have appeared from time to time vary so considerably, both as to total amounts and details that it is very difficult to reconcile them.

The earliest account relates to the last half of the seventeenth century and is, I believe, from Miguel Ozorio y Redin. It states the total product of grain to be 120 million bushels, two-thirds wheat and rye, and one-third barley and oats. The population is believed to have been at that time about seven and a-half millions. The product adduced would therefore equal 16 bushels per capita per annum, which seems excessive. The account is, however, not to be rejected as valueless. The numbers of the population supposed to have existed at that time are by no means certain; the consumption of grain was probably greater, and of meat, less than at more recent periods. The account may not relate to an average year, but an exceptionally good one; finally, it is to be presumed that, though not specified, the product of chestnuts, dry legumes and other substitutes for grain, is intended to be included in the principal articles mentioned.

The next account, quoted by Macgregor from the "Census and Returns" of 1803, is as follows:

Breadstuffs—Product of Spain, in 1803.

	Hectolitres.	Bushels.
Wheat	17,060,000	47,768,000
Barley	8,321,000	23,298,800
Rye	5,626,000	15,752,800
Oats, maize, rice, etc	3,619,000	10,133,200
	34,626,000	96,952.890

We have here, a total product of some 97 million bushels of grain for a population of some 10,400,000 souls, an average of about nine and a-half bushels per capita. Bearing in mind that potatoes, chestnuts and legumes are omitted, I am inclined, for various reasons, to regard this estimate as substantially correct.

Mr. L. S. Sackville West, H. B., M. Secretary of Legation at Madrid, in reporting to his Government, under date of July 1, 1865 (Rep. Sec. Leg., 1866, 179), states that "fifty years ago, Spain, say with a population of 10,000,000, produced 38 million hectolitres (106½ million bushels) of grain." This statement corroborates the census and returns of 1803.

An estimate for the year 1849 appears in Mr. Joseph Fisher's work on *Food Supplies* (London, 1866), and gives the total product of cereals (omit-

ting maize) at 12,584,322 quarters, or say 100,674,576 bushels. Allowing 20 million bushels for maize and two million bushels for rice, we have a total in round figures of 123 million bushels of grain. The population at that time amounted to about 13,700,000, and the product of grain was therefore about nine bushels per capita, a proportion which appears to be substantially correct.

Says Mr. Sackville West: "In 1863, France produced * * * and Spain 66 million hectolitres of grain." As it is evident from the context and also from the fact that the cadastral census of Spain was taken in 1857, that that is the year to which Mr. West refers in regard to Spain, I have taken the liberty to so treat his statement. Sixty-six million hectolitres amount to 184,800,000, bushels, and this, among a population of 15,000,000, amounts to an average of about 12⅓ bushels each. If Mr. West's statement is applied to the year stated, 1863, when the population was a fraction over 16,000,000, the result would be an annual product per capita of about 11½ bushels. From both of these results I am inclined to believe that Mr. West's estimate includes potatoes, chestnuts and legumes. In such case I regard it as substantially correct.

For the year 1857 we have another account. This was given by no less an authority than the late Albany W. Fonblanque, the accomplished statistician of the British Board of Trade, and is published in the *Agricultural Returns* of H. B. M. Board of Trade for the year 1867. Ever since that year it has been regularly published in the Returns as the "estimated quantities of the principal kinds of corn and potatoes produced in Spain," and it therefore appears in the A. R. for 1874, over the signature of Mr. A. R. Valpy, Mr. Fonblanque's no less accomplished successor. Notwithstanding these high authorities and the official sanction which the publication of the account in such a work conveys, I am compelled to regard it as defective. It states that Spain produced in 1857, 168,140,692 bushels of wheat; of barley 76,427,587 bushels; and of rye, 24,727,483 bushels; together, 269,295,762 bushels of grain; an average of nearly 18 bushels per capita of population, to say nothing of maize and patatoes, which are important articles of consumption in Spain; nor of oats, rice, buckwheat, millet, chestnuts nor legumes—proportions that so radically differ from all other accounts as to lead to the suspicion that error has been committed in the conversion of the quantities.

For the year 1868 we have the account laid before the Statistical Congress at the Hague, by Mr. Samuel B. Ruggles, of New York. This is as follows:

Cereal product of Spain, with Balearic Islands, in 1868: wheat, imperial bushels, 87,732,150; rye, 44,427,940; barley, 47,731,500; oats (included with other cereals); buckwheat and millet, 22,975,300; maize, *nil;* rice, 2,000,000; total 204,866,890 imperial bushels. With the exception of rye which is over-estimated, and buckwheat and millet, the estimated product of which ought to be credited almost entirely to maize, I am inclined to regard Mr. Ruggles' account as substantially correct. The total sum

gives an average allowance of grain per capita of about 12⅓ bushels, which agrees with all of the estimates that are regarded as reliable.

For the year 1873, I have the following very explicit and detailed account, recently transmitted to me from Spain:

Account of the produce of Breadstuffs in Spain and the Balearic and Canary Islands for the year 1873.

BREADSTUFFS.	BUSHELS.	BREADSTUFFS.	BUSHELS.
Wheat	110,000,000	Rice	2,000,000
Barley	40,000,000	Buckwheat and Millet	5,000,000
Rye	20,000,000	Potatoes	25,000,000
Oats	3,000,000	Chesnuts	3,000,000
Maize	25,000,000	Dry Legumes	5,000,000
		Total	238,000,000

Reckoning the population in 1873 at about 17,200,000, the result is an average of all kinds of breadstuffs of 13.8 bushels per capita, and of grain alone 170,000,000 bushels, or about 9.9 bushels per capita. Allowing 23,000,000 bushels for the export of grain, the consumption would be 147,000,000 bushels, or 8.5 per capita.

I am inclined to believe that this account, though it agrees very well with those relating to previous years, underrates the true product of Spain, though perhaps only to a small extent. Altogether it is the best account we have, and must be taken as an exponent of Spain's present capacity to produce breadstuffs until a more definite account can be rendered. Grouping together such of the preceding accounts as seem reliable, we have the following comparative results:

COMPARATIVE ESTIMATE OF THE BREADSTUFFS PRODUCT OF SPAIN AT VARIOUS PERIODS.

Year.	*Grain. Bushels.*	*Potatoes, Chestnuts and Legumes. Bushels.*	*Total Breadstuffs. Bushels.*	*Population. Approximative*
1803	97,000,000			10,400,000
1849	123,000,000			13,700,000
1857			184,800,000	15,000,000
1868	205,000,000			16,700,000
1873	203,000,000	33,000,000	238,000,000	17,200,000

These results, in the transcendantly important department of agricultural production, show the same remarkable advance during the past twenty years as has already been noticed in other respects, and fully establish the claims set forth at the outset of this paper.

It will perhaps be noticed that, except as to exports in the year 1873, I have taken no notice of the imports and exports of breadstuffs. The reason for this was that among the periods under review relating to agricultural production, 1873 was the only year in which the foreign commercial movement of breadstuffs appeared worthy of note.

GRAVITATING WAVES.

By Pliny Earle Chase,

Professor of Physics in Haverford College

(*Read before the American Philosophical Society, January 1st*, 1875.)

In my various discussions of luminous and gravitating harmonies, I have shown many slight discrepancies, between theoretical and observed results, which are of the same order of magnitude as planetary orbital eccentricities. Although it would be unreasonable to look for any speedy and complete solution of those discrepancies, I think it right to try such questionings of nature, as seem likely to lead to a fuller understanding of the common laws of molar and molecular force.

The hypotheses of Newton and Le Sage seem necessarily to involve a repellent action of the æthereal waves between two bodies or particles, as well as a centripetal appulsion by the exterior waves. If the ratio of these activities is discoverable, it seems reasonable to look for it in the relative positions and motions of the three controlling bodies in the principal subdivisions of our system,—Sun, Earth, and Jupiter.

In the simplest form of gravitating or other central revolution, the tangential "lines of force" are continually deflected, by radial centripetal waves, so as to form a system of semi-circular undulations. The velocity of circular orbital motion communicated by any central force being represented by radius, (or twice the virtual centripetal appulsion), the length of the aggregating radial wave : the length of the deflected semi-circular wave : : $1 : \pi$. But the length of the wave of dissociation* : the length of the limiting wave of aggregation : : $2 : \pi^2$. Combining these proportions, we find that the length of the dissociating or repelling wave : the length of the primitive wave : : $2 : \pi^3$, or : : .0645 : 1. If the repulsion of the surfaces of two bodies from their common centre of gravity is $\frac{2}{\pi^3}$ of the appulsion towards the centre of gravity, the distance of the common centre of gravity from the principal centre of mass $= \left(1 + \frac{2}{\pi^3}\right) r = 1.0645\, r$.

The mean distance of Jupiter from Sun being $1117.87\, r$, the mass of (Sun ÷ Jupiter) should be, to accord with this hypothesis, 1117.87 ÷ 1.0645 = 1050.14.

I have already shown that the limit of dissociating velocity (v_0) for Jupiter and Earth, corresponds to the limit of planetary velocity for Sun, thus indicating an equality of radial and tangential action, such as we might reasonably have anticipated. If we adopt Cornu's determination of the

* Proc. Am. Assoc., Hartford Meeting, 1874; Am. Jour. Sci., "Velocity of Primitive Undulation," Nov. 1874.

velocity of light, so as to derive all our data from observations which are always susceptible of verification, we find the following accordances.

I. For Earth:

$$v_2 = \frac{2}{\pi} v_\rho = \frac{4r}{t} = \frac{15851}{24} = 660^m.46 \text{ per } h.$$

$$v_1 = \sqrt{2\,gr} = \sqrt{\frac{32\times7925.5}{5280}\times3600} = 24{,}950^m.2 \quad \text{" "}$$

$$v_0 = \frac{gt}{2} = \frac{v_1^2}{v_2} = \frac{32\times43200\times3600}{5280} = 942{,}545^m \quad \text{" "}$$

$v_0 \div \sqrt{214.86}$ = approx. Solar $\sqrt{gr}$ at $\oplus$ $= 64{,}302^m$ " "

Multiplying by 8766^h and dividing by 2π we get, for an approximate estimate of Sun's distance, $89{,}711{,}000^m$ (α).

The distance corresponding to Cornu's estimate of the Solar parallax ($8''.86$) is $(206264.81 \div 8.86) \times 3962.75 = 92{,}255{,}000^m$ (β).

Dividing (β) by (α) we obtain 1.0284, which is nearly equivalent to $\sqrt{1.0645}$.* Therefore v_0 for Earth is nearly, if not precisely, equivalent to planetary velocity in a circular orbit at the centre of gravity of Sun and Jupiter.

II. For Jupiter:

The uncertainty of the elements in this case precludes the possibility of any minute verification of hypothesis, but it is evident that the point at which the gravitating waves must act, in order that the dissociating velocity of Jupiter $\left(v_0 = \frac{gt}{2}\right)$ may equal the limit of planetary velocity, must be at or near Jupiter's surface. For the mass of (Jupiter $\div$ Earth) $= \frac{1}{1050.14} \div 4.432 \left(\frac{8.86}{1000}\right)^3 = 308.92$. The apparent diameter of Jupiter is variously estimated, from $3'\,13''$ to $3'\,25''.5$ at Earth's mean distance from Sun. Dividing by $2\times8''.86$, we find for diameter $(♃ \div \oplus)$ 10.89 @ 11.60, and for g $(♃ \div \oplus)$ 2.3 @ 2.6. The estimates for the time of rotation (t) vary between $17700^{sec.}$ and $17880^{sec.}$

Therefore:

$v_0 = \frac{gt}{2} = gt\,\frac{(32\times3600)}{5280} = 888{,}219$ @ $1{,}014{,}283^m$ per h. The geometrical mean of these possible extreme values, differs from the value found for Earth by only 7–10 of one per cent. The other planets, both of the Jovian and of the Telluric belt, would all be dissipated and absorbed in their primaries before they had attained the dissociating velocity of Jupiter and Earth. This intimate dependence of planetary aggregation, dissociation, and rotation, upon Solar attraction, and the dependence of Solar aggregation, dissociation, rotation, and planetary revolution upon

* $\sqrt{1.0645} = 1.0317$.

the velocity of light, therefore point to the same unity of force as has been indicated by the modern researches in heat, electricity, and magnetism.

III. For light and Terrestial Gravity :

If g = equatorial gravitating velocity, and t = a sidereal year, $gt \div \sqrt{1 + \frac{2}{\pi_3}} = 365.256 \times 86400 \div 5280 \div \sqrt{1.0645} = 185{,}380\ m$ per second. This corresponds to the velocity of light, giving a Solar distance of $497.83 \times 185{,}380 = 92{,}287{,}700$ miles.

VI. Wave Lengths:

The primary radius, $1.0645 \times 92{,}255{,}000 \times 63360 \div 214.86 = 28{,}959{,}800{,}000$ inches. Dividing by the number of wave-lengths* in radius, 66456 $(10,^{11}$, we find for the value of one wave length, $u = \frac{1}{229131}$ *in.* The radial waves should be accompanied by deflected tangential waves of three kinds, viz. :

1. $w_2 = \frac{\pi}{2} u = \frac{1}{145869} in.$ = wave of simple rotation.

2. $w_1 = \pi u = \frac{1}{72934} in.$ = wave of circular orbit.

3. $w_0 = 2\pi u = \frac{1}{36467} in.$ — wave of virtual fall *doing work* = Solar orbital wave $= 4\ w_2$.

According to Eisenlohr,† the wave-lengths in the diffraction spectrum are as follows :

Upper actinic,	$\frac{1}{143880}$ *in.*
Lower actinic, or upper luminous,	$\frac{1}{71940}$ *in.*
Lower luminous, or upper thermal,	$\frac{1}{35970}$ *in.*

V. Miscellaneous :

Among other note-worthy accordances in this connection are the following :

1. The approximate equality of Mass (♃ ÷ ☉) to distance fallen through in (time of fall to centre ÷ time of circular revolution).

2. The equality of orbital *vis viva* in Jupiter and Saturn.

3. The equality in the ratio of orbital *vis viva* (♆ ÷ ♁) to the ratio of orbital to radial waves ($w \div u$).

4. The connection of Sun's radius, modulus of light, and the limits of the planetary system ; the velocity of planetary revolution and Solar rotation being equal at 37 ☉ ; v. of revolution at 37 ♆ $\left(= \frac{M}{2}\right)$ — v. of rotation at ☿.

5. The stellar-solar parabola, between α Centauri and Sun, and its relations to the planetary distances.

* *Loc. cit.* † Am. Jour. Sc. [2] xxii, 400.

AN OBITUARY NOTICE OF MR. JOSEPH HARRISON, JR.

By Coleman Sellers.

(*Read before the American Philosophical Society, February* 19, 1875.)

When we review the life of any prominent individual and attempt to analyze the motives that seem to have actuated him, and which may have led to his success, we can scarcely avoid noting a resemblance to other lives; we find the same results following the same general course of action in all. This orderly sequence of events leads us to think we are subject to some fixed law, with which law seemingly accidental causes may interfere to give endless variety in detail, yet not materially to alter the result. That the good and obedient son, the industrious apprentice, the faithful workman, should in time grow to be the much-respected and influential citizen, seems so natural and orderly that life in such a case appears as if "it was a sum duly cast up giving results in particular figures."

In rendering tribute to the memory of our late associate, Joseph Harrison, Jr., by reviewing the prominent events of his life and recording the results accomplished by him, the high position held by him in his latter days demands a careful consideration of the orderly growth of a life which had its beginning in the enforced economy and habits of industry of the apprentice and in a few years of home training.

So far as any chronological record of his life is needful, the task you have honored me by imposing on me is rendered easy by his own forethought in presenting to his children a well-written autobiography so clear and precise in its narrative that it is difficult to avoid the use of his own words in giving here the outline of his life. Previous to the War of Independence Mr. Harrison's ancestors seem to have been well-to-do; but his grandfather, who was a large land-holder in New Jersey, entered the army, and afterwards neglecting his personal affairs, died in 1787, leaving but little for his family. His son, Joseph Harrison, was sent to Philadelphia when fourteen years old, and was employed by Mr. Charles French, grocer, whose daughter he married in 1803. He seems to have been unfortunate in business, and the subject of this memoir was born, as he says, in the dark hours of his family history. This was on September 20th, 1810, so that Joseph Harrison, Jr., was 63½ years of age at the time of his death, March 27th, 1874.

In his youth he seems to have been fond of reading the few books at his command, and very early he evinced a strong inclination towards mechanical pursuits. Following this bent after what schooling he could obtain before he was fifteen years old, he was at that age indentured to Frederick D. Sanno, in the old district of Kensington, to learn the art and mystery of steam engineering. In about two years the failure of Mr. Sanno canceled his indentures. He considered the change that this necessitated a good thing for himself, as he was then enabled with some

experience to enter a better shop upon more advantageous terms. His second employer was "an uneducated Englishman, but a very good workman," and in his shop he soon became more proficient, and at the age of twenty, before he was yet free, he was made foreman of part of the establishment and had under him thirty men and boys. At the expiration of his apprenticeship to James Flint, he continued with the firm, then Hyde & Flint, for one year, and left them to take employment with Philip Garrett, a Quaker gentleman, who had a small shop for the manufacture of "small lathes, presses for bank-note engravers and the like." He remained with Mr. Garrett until 1833, then went to Port Clinton, Pennsylvania, to start a foundry for Mr. Arundus Tiers, with whom his father was engaged as accountant. This was the end of the varied experience as a mechanician preceding his career as a constructer of locomotives. In 1834 he was employed by William Norris, then engaged with Colonel Long in building locomotives (the design of the latter-named gentleman). Here he obtained his first insight into that branch of the mechanic arts that was afterwards to be his life-work. He seems to have considered this part of his mechanical education as of a negative character, as he said "he had been schooled in the midst of failures," so that when in 1835 he was engaged by Messrs. Garrett & Eastwick as foreman, and was intrusted with the designing of the locomotive "Samuel D. Ingham," he endeavored to avoid what he believed to be "the errors with which he had been made familiar." This engine was considered a success, and led to the construction of others like it. On December 15, 1836, he married Miss Sarah Poulterer, whom he had met in New York in January, 1835. After his marriage, in 1837, he became a partner in the firm of Garrett, Eastwick & Co., investing his skill, the only capital he had, in the venture. In 1839, when Mr. Garrett retired from business, the firm took the title of Eastwick & Harrison. In 1840, he designed an engine at the request of Mr. Moncure Robinson, of the Reading Railroad. This engine, named the "Gowan & Marx," "proved to be, for its weight (eleven tons), the most efficient locomotive for freight purposes that had been built anywhere." This event seems to have been the turning point in his life, for two Russian Engineers, Colonels Melnekoff and Kraft, were in America at that time studying the railway system of this country. They saw this engine and were so well pleased with its operation that they procured tracings from the drawings of it, and took them to Russia. This style of engine seems to have been adopted by the authorities in Russia, and Mr. Harrison was invited to visit that country, money being forwarded to defray his expenses. He was cordially received, and in 1843, in association with his partner, Mr. Eastwick, and Mr. Thomas Winans, of Baltimore, he concluded a contract with the Russian Government to build the locomotives and rolling stock for the St. Petersburg and Moscow Railway. This contract amounted to three million dollars; the work to be done in five years, it being conditioned that all the work should be done in St. Petersburg, by

Russian workmen or such as could be hired on the spot. It was at this critical period of his life that he experienced the advantages of his early training. The great work was to be carried on in a land where every kind of corruption was the rule; where all the subordinate officials of the land fed and fattened on the commissions collected from those who had contracts with the Government. The payments were to be made as the amount of work completed; inspectors were to examine into the work done, and report as to the correctness of the monthly statements. The inspectors, for a pecuniary consideration, were ready to endorse any statement, no matter how false, yet would threaten annoyance if they were not bribed. This, added to the trouble of working inexperienced hands, made the task of the contractors the more difficult. Mr. Harrison had been told by Count Bobrinski that the officials would wear them out long before the term of their contract was ended. The Count, meeting him in after years, spoke of the conversation and said the success of the American contractors had been a mystery to every one. They did not understand how that contract and subsequent ones could have been carried out without resorting to the usual practice of doing Government work in that country. In their efforts to act fairly and honestly in their work they seem to have been upheld by all the higher officers, and their course won the confidence and approval of the Emperor himself, who was a careful observer of the work as it progressed. In all of Mr. Harrison's successes under these many difficulties his character as a cautious, prudent and strictly upright man was manifest, and was clearly the outgrowth of his early training. The confidence inspired led to other contracts, as in 1850 to one to maintain the moveable machinery of the road already equipped by them for the term of twelve years. This contract bears date August 25, 1850, and the parties to it were Messrs. Joseph Harrison, Jr., Thomas Winans and Wm. L. Winans, the latter having purchased Mr. Eastwick's interest in the contract of 1843, previous to its completion. As an evidence of the Imperial favor, valuable diamond rings had been given to the members of the firm, and Mr. Harrison was made the recipient of the ribbon of the Order of St. Ann, to which was attached a massive gold medal, upon which was inscribed in the Russian language the words "For zeal." This honor was conferred upon him at the time of the completion of the bridge across the Neva, accomplished by the firm during the time of the first contract, which had been extended one year for this purpose. During Mr. Harrison's residence abroad he seems to have noticed with interest the effect of the art galleries on the working people, and when he returned home he at all times advocated the foundation of public art museums open to the people at all times, and was active in the establishment of one in our Park. He frequently expressed his opinion of the need of art culture in improving the taste of artisans and rearing among us competent designers. An appreciation of the beautiful prompted him to collect about him many paintings and other works of art, which served to beautify the home he soon built for himself in his native city.

It was in 1852 that he returned from abroad and located himself in Philadelphia to enjoy the rest from active business cares needful after his many years of labor. The ample means that had rewarded his enterprise abroad enabled him to gratify his taste for art and later to do good service to the world in his crowning achievement yet to be alluded to—his safety steam-boiler.

Soon after his return to America he built the house which was his home for the remainder of life. The planning and arranging of many of the seemingly minor details of this building gave him pleasing employment for some years. It was at this time that the writer became acquainted with him, was made aware of his mode of thought and his ability as a mechanic. He can bear testimony to the fact, of interest it may be to mechanics only, that hidden under the plaster of that house are very many ingenious devices to insure stability and to economize space by the use of iron in forms and shapes not commonly known to architects at that time. These were special adaptations suggested by a mind fertile in resources, familiar with the use of iron and possessed of a knowledge of how to form it and use it to good advantage.

He chose to invest much of his means in real estate, and numerous fine buildings which serve to beautify the city were erected by him. At one time he advocated the concentration of all the railroad termini at one central point in the city, and to combine with the depot commodious hotel accommodation. With this end in view he attempted to purchase land, not so much as a speculative movement as to render such a plan possible. It is believed that he felt disappointed when this scheme was shown to be impracticable. In this connection it may be well to mention that in 1860 he desired to return to Europe with his family, and upon the eve of his departure he sent a message to the writer requesting him to call to see him. He then said that he desired to tell one who understood him why it was that he was about to leave so pleasant a home. He spoke of the many plans he had had in view to benefit the city, and said with sorrow that he felt that his motives had been misconstrued, and in some respects his efforts had been failures on this account. He desired to go abroad, to be absent for some years; that while away his plans should be forgotten and when he returned he could begin again in some other direction. Previous to this, in 1858, he mentioned to his friends an invention he had made to obviate the danger of disastrous explosions in steam-boilers. Starting with the idea that the strength of any structure is the strength of its weakest point, he aimed to construct a steam-boiler built up of units of some given strength. He claimed that a sphere of metal, say of cast iron, might be formed with its walls not more than three-eighths of an inch in thickness and of such a diameter as would establish its bursting pressure at may be 1000 pounds per square inch. Such a sphere would doubtless be safe for the pressures usually required by users of high-pressure steam. He proposed casting these spheres in groups of two and four, uniting them in one plane by curved necks and making openings at

right-angles to these uniting necks in the form of half necks with rebate joints to match with similar joints on the other groups. A group of four balls might be called a unit, and a pair of balls a half unit, corresponding with whole bricks and half bricks in building usage. Each of these units would possess a strength measured by the strength of each individual ball or sphere forming part of the unit, and a boiler structure built up in any form and to any extent would have a strength identical with the strength of each unit used in its construction. As the various groups of balls were to be held together by bolts passing through the opening from end to end of the pile, it was presumed that these bolts would stretch under an unusual strain and thus permit a leak at the joint, so, making, as it were, a great many safety-valves to relieve the strain. It was of primary importance that the walls forming all the sides of these groups of balls should be of uniform thickness. To accomplish this result a knowledge of the founding art would be needed. When Mr. Harrison presented this idea to the public he had evidently carefully considered all the difficulties that would occur in the practical realization of it and in its introduction. He had already perfected his plans and was prepared to direct the preparation of the patterns from which these groups of spheres could be cast of uniform thickness of metal, on what is technically known as a green-sand core, so that the first group or unit cast was perfect in all respects. He had also matured a plan of dressing the rebate-joints in the groups by machinery, thus insuring accuracy of size and making the parts interchangeable, without depending on the skill of the workman.

The first boiler built on this plan was tried in the establishment of Messrs. William Sellers & Co., in this city. It was erected in the spring of 1859, and for many months supplied all the steam needed in that establishment. To avoid all risk from so novel an experiment the cast iron boiler was worked for several months at Mr. Harrison's own expense, fires being kept under the wrought iron boilers in readiness for use should the new one give out. It may be well to mention that from that time to the present writing, these boilers have been in constant use in the same place under some of the many forms afterwards designed. The invention of this kind of safety boiler marked a distinct era in boiler construction; and whatever may be the ultimate history of this invention, whether its use be continued in future, or it be superseded by other forms, it is nevertheless a well-established fact that its inception preluded all the forms of sectional safety boilers now in use which are presented, each with some special claim for efficiency, durability and safety. Mr. Harrison did not claim for his invention diminished first cost, nor did he anticipate any greater efficiency than was obtainable by any first-class boiler, but he was sure of a greater safety in the use of high-pressure steam and he thought that the use of his invention might render possible the safe employment of higher pressures, if desirable, than was before considered possible with any of the ordinary types of wrought iron boilers.

Had Mr. Harrison presented to the world no other work but this his life would have been justly classed among the benefactors of our race. As it was, this invention was a crowning achievement of a life full of usefulness.

Much of the detail of the machinery needed to produce these steam-generators was perfected during the years he was abroad, between 1860 and 1863, he returning to America in the summer of the latter year. After his return he erected a factory for the production of his boiler, and in the arrangement of this establishment he evinced mechanical ingenuity of the highest order. He introduced many novelties in the methods of founding; in modes of cleaning the castings and in the general system of proving the work when done. He aimed to so systematise the work as to dispense with skilled labor as far as possible, using machinery in its place.

As Mr. Harrison had passed through the various conditions of life as an apprentice, as journeyman, as foreman, and then as principal in his career as a mechanic, and had achieved proficiency as a skilled workman before the days of modern machine-tool and labor-saving appliances, he naturally believed such training to be the proper one for the youths of our day, and in a measure deprecated the practice of keeping young men too long at school if they looked toward success in the workshop. As this was emphatically announced in public near the end of his useful life, it may be well to give it more than mere mention. In the journey of life there are in the memory of all persons events which stand as landmarks on the road; certain points that appear prominently in view and are remembered at all times in their proper order. In looking backward along this road traveled but once, these important events are clearly seen, no matter how long the road may have been, and the more distant ones seem crowded in close proximity, the space between them having been lost to view, so that the sum of life seems made up of the strongly marked events only. If these events lead step by step towards affluence and position, they must seem to the traveler on that road to have surely marked it as the only path that could have led to such results. Mr. Harrison saw in his early application to the workbench, in his early industry grown to habit, in his enforced economy in boyhood, the foundation of own his success. He prided himself on his skill as a workman, and although he ceased to work with his hands when he took control of his greater enterprises, yet he felt that in learning how to work he had stored his mind with the knowledge of most use to him as a master-mechanic. Hence we are not surprised to hear him advise the need of early apprenticeship to those who desire to become mechanics. His expression, "In mechanical and other trades it is the education of the work shop and not the education of schools, that is most required," was prompted by the bias of his own career, and was strengthened by observation of the course of many others who, like him have, from rough beginnings, achieved distinction. His life, like the lives of those many others, was a long period of

study. He pursued such knowledge as he needed, because he did need it, and for its use to him he loved it. The varied incidents of his life abroad, the persons with whom he came in contact, aided his mental culture. His manual skill secured his advancement in the workshop. The knowledge he needed was obtainable from daily observations only ; it was not written in any book ; mere skill as a workman would not give him this knowledge, but it did give him opportunities of observation, and he was ready to avail himself of the fund of information so collected. His opinion in the matter of the education of mechanics has weight and needs careful consideration. He had but to point to his own career as an example to prove the rule he laid down. There are comparatively few of the youths of the present day who care to go through the years of apprentice life. The tendency of all modern schooling is to make tradesmen of them, not mechanics. Of these few who from strong inclinations would lead a mechanic's life but a still smaller proportion can find places in the work-shops of the land. Hence the need of schools that may take the place of these work-shops and give to our young men the very knowledge that Mr. Harrison claimed they most needed. He did not believe that mere manual skill would insure success ; he knew that much learning was needed, but he believed that knowledge was within the reach of every one who would diligently seek it. He says of himself that while quick to learn at school and was in some branches at the head of his class, yet strange to say he never wrote a composition at school, and did not write his first letter until after he was twenty years of age.

So far as technical education was needed by him in his career as a locomotive-builder, it must be borne in mind that it was in that direction unobtainable when he most needed it. No books were yet written to guide him ; the locomotive-engine was a new thing, railroads were yet young. His mind grew with the progress of the art, and he did his full share in that progress. Had he continued to the end of his life at the same work he would have still grown with his work, and would doubtless have still been a master-mind in that direction. But it must be remembered that the work he did and that others have done in advancing the mechanic arts, makes now more learning needed on the part of one who would take up engineering as a science at the place where he and they left off.

Towards the close of his life, Mr. Harrison turned his attention towards recording some of his thoughts and experiences. After writing some verses, entitled "The Iron Worker and King Solomon," intended for the amusement and instruction of his children, and designed to impress their minds with the "value of what is but too frequently thought to be very humble labor," he published a folio volume of over two hundred pages, containing this poem and some fugitive pieces accompanied by his autobiography, and many interesting incidents of life in Russia, also all the leading particulars of the invention of his boiler. He wrote a paper on the part taken by Philadelphians in the invention of the locomotive, an account of the completion and opening of the bridge over the Neva in

Russia, and a paper on steam boilers. In all these he showed considerable literary ability and fully sustained his claims to the possibility of self-education.

The dignity of labor was a favorite theme with him, and he held in high esteem the producers in the world's economy. He said that when he returned to America he found that undue prominence was given in society to mercantile pursuits and an underrating of mechanical occupations. During the year 1859, he gave a dinner party to fifty gentlemen, who were invited ostensibly to hear a lecture by Dr. Hays on the Open Polar Sea, but planned in reality to bring together certain persons in different positions in life who were representatives of different classes, and who were not well-known to each other. This object was fully explained by him to the writer, and was much dwelt upon in his mind at that time. He said that banking facilities were extended to merchants what were not accorded to mechanics; that in his early career he had felt this want of confidence very keenly, and he earnestly desired to help place the producer in his proper place in the opinion of the world as to usefulness. He lived to see a great change in this respect due somewhat to his own exertions, but may be more to the enforced need of exactness of mercantile pursuits in the conduct of the business of the manufacturer.

His interest in the fine arts was continued up to the close of his life, and it was known that he desired to give to his valuable collection some permanency, but pain and suffering came upon him too soon and thus suddenly checked much of his exertions. Only those who were near to him knew how much he suffered during the last few years of his life, and with what patience he bore a malady which he was conscious might at any time end his life in pain and suffering, and of which he yet hoped he might be cured. It is probable that his malady seriously affected him as early as 1869, for a letter dated August 12th of that year, addressed to him at Saratoga by his physician, says in speaking of the cause of his decease: "I have seen many cases of it in my life and they have all finally thrown the disorder off." This, however, was not to be in his case, and the best medical skill of the land only gave him partial relief, and five years of great suffering were only ended by the hand of death.

These years of illness did not prevent him from taking a great interest in all that was going on in the world of art and science, and he busied himself much in writing. He had lived to see his children grown up and settled. He leaves behind him a widow and six children—William, Henry and Annie, who was born in this country before he went to Russia; Alice M'Neil, Marie Olga and Theodore Leland, born in Russia, and Clara Elizabeth, born in America after their return. In his home life he was an affectionate husband, a kind and indulgent father, and at all times a dutiful son. The words written by himself to his family are full of love and kindness. His book for their use and comfort was dedicated:

"To Thee

Who Hast Been

For More Than Half My Life

My Truest Friend,

My Counselor,

My Wife."

During the latter part of his life he was connected with the Protestant Episcopal Church,* and had been a regular attendant at Divine service at all times. He made no outward show of religious bias, but ever bore himself as an honest, upright citizen striving to do what was right. His worth and ability led to his being asked to fill many positions of honor and trust, and he received many substantial evidences of appreciation of his work. For what he had done in the direction of safety in steam-boiler construction he was, on May 30, 1871, made the recipient of the great gold and silver Rumford medals by the American Academy of Arts and Science "for the mode of constructing steam boilers invented and perfected by" (Mr. Harrison), which "secures great safety in the use of high-pressure steam, and is, therefore, an important improvement in the application of heat."

Mr. Harrison was elected a member of this Association July 15, 1864; signed the Constitution and was introduced to the presiding officer, Judge Sharswood, Vice-President, December 2d, 1864, having accepted his membership by letter dated September 26, 1864. He was also a member of other learned societies, but with the exception of few papers read by him he did not take a very active part in the business of any of them. Of him it cannot be said that fortune was more kind than to others. His success was the legitimate outgrowth of his beginning. There may be some who "when they have planted their feet on the first rung of a ladder must needs mount;" with some the ladder of life is an unbroken one and to fall in climbing can be but from sheer carelessness. But his life was not without many trials. There were many missing rungs in that ladder, and these gaps, sometimes very wide, had to be crossed with prudent care. To him was intrusted the keeping of many talents, and he proved himself a good and faithful steward.

* Mr. Harrison was confirmed by Rt. Rev. Wm. Bacon Stevens, at the Church of the Holy Trinity (Nineteenth and Walnut streets), Sunday, May 2d, 1869. Rev. Phillips Brooks, Rector.

AN OBITUARY NOTICE OF CHARLES B. TREGO.

By Solomon W. Roberts.

(*Read before the American Philosophical Society, Feb.* 19, 1875.)

Charles B. Trego was born near Newtown, Bucks County, Pennsylvania, November 25th, 1794.

His ancesters were French Huguenots, who emigrated to England and, some of the family having become members of the Society of Friends, came over to America in the time of William Penn and settled at Chester, on the Delaware, and afterwards removed to Bucks County.

His boyhood was passed on his father's farm, and he went to school in the neighborhood; but not liking the occupation of farming, and anxious to improve himself, he began when young to teach school, and at the same time to study German; which was the language commonly spoken by many of the farmers. His handwriting was remarkably regular and beautiful, and continued to be so even to old age.

About 1821 he removed to Philadelphia, and taught a school in the city, living for a time in the same house with a German teacher of languages, and adding to the study of German, that of French, Spanish, Latin, Greek and Hebrew.

He taught school until he was about forty years of age, and studied Geology, Mineralogy and Botany, making a special study of Geology.

Although much occupied in studying and teaching, he took a lively interest in public affairs. In 1835 a political change took place in Pennsylvania, and the party to which he belonged was successful, electing the Governor and controlling the Legislature; and Mr. Trego was elected a member of the House of Representatives from the City of Philadelphia. He was also re-elected in the following year.

Soon after his election he introduced and was mainly instrumental in having enacted into a law, the Act for the first Geological Survey of Pennsylvania. It is understood that the post of State Geologist was offered to him by Governor Ritner, and declined by Mr. Trego. Professor Henry D. Rogers, received the appointment, and began the survey in 1836. In 1837, Mr. Trego became an assistant of Professor Rogers, and he continued in the survey until 1841; when he was again elected to the Legislature, and was re-chosen, year after year, until 1847; when he declined a re-election, and was succeeded by the writer of this obituary notice.

Mr. Trego was an intelligent, careful, pains-taking and honest legislator, and a faithful servant of the City of Philadelphia and of his native State. His knowledge of the different parts of Pennsylvania, and the character of his culture, gave him broad views, and added to his influence with his fellow members, and to his usefulness as a member from the city; as in many cases members from the country show an unwilling-

ness to be influenced by those from the city, unless they find them to be familiar with the interior of the State.

There is no doubt that the degree of success that attended the first Geological Survey, was largely due to Mr. Trego's influence at Harrisburg.

In 1843 he prepared and published a work on the Geography of Pennsylvania, which is a book of nearly four hundred pages, containing a large amount of information concerning the State. In the preface he says that "in the course of his duties as Assistant State Geologist, during four years, and on various other occasions, the author has visited most parts of the State, and has thus enjoyed opportunities of acquiring much local information concerning the different subjects embraced in this work."

He also prepared a mass of materials with the view of writing the history of the City of Philadelphia, and it is to be regretted that he never completed it.

Mr. Trego was, for some time, Professor of Geology in the Scientific Department of the University of Pennsylvania, and delivered lectures upon it in that institution.

On the 20th of January, 1843, more than thirty years ago, four persons who had been active in the affairs of the Franklin Institute, were elected members of the American Philosophical Society. They were Charles B. Trego, Charles Ellet, Jr., Ellwood Morris and the writer of this notice, who is now the sole survivor of the four.

On the 7th of January, 1848, Mr. Trego was elected one of the Secretaries, and was soon after chosen Librarian; and on the 15th of August, 1851, he was elected Treasurer of the Society, which office he retained until his death, a period of more than twenty years; and he also continued until the close of his life to be one of the Secretaries.

On the 30th day of June, 1854, the corporate existence of the Districts, Boroughs and Townships of the County of Philadelphia ceased, and they were merged in one municipal corporation with the City of Philadelphia; and about that time Mr. Trego removed into what had been the District of Spring Garden, and at once identified himself with the political and other interests of that part of the consolidated city.

From 1856 to 1862 he was a member of the City Council, and for four years of that time he was President of the Common Council. His long Legislative experience had made him very familiar with the rules of order of representative bodies, and his uprightness and firmness fitted him to preside. In 1863, when about sixty-nine years of age, he retired entirely from public life.

From that time until shortly before his death, he devoted himself, during eleven years, very much to the business and to the interests of the American Philosophical Society; not only attending the meetings, but occupying himself, for much of his time during business hours, in the Library of the Society. Here he was fond of seeing his old friends, and of talking over curious incidents in the history of the City and State.

He died of the disease of the heart, on the 10th of November, 1874; at which time he was within fifteen days of being eighty years old. He was buried in the burial-ground attached to the Friends' Meeting House, at Wrightstown, Bucks County. His widow and one son constitute his surviving family.

A number of the facts contained in this brief biographical notice, have been communicated to the writer by Mr. Trego's son, Mr. F. A. Trego, who has sought among his father's papers since his death, for his private journal, but has not been able to find it.

In looking back over the life of Mr. Trego, we see that while it was not distinguished by any very remarkable incidents, he has left behind him a good record.

He maintained the good reputation of the race from which he was descended; and living to the age of nearly four score years, he was useful to the end of his career, and as the faithful Treasurer of the American Philosophical Society, and the collector and disburser of its funds for nearly a quarter of a century, his memory well deserves to be honored by the members of the Society, as that of a good citizen, a lover of science, and a faithful steward of the talents with which he was intrusted.

ANALYSES OF ROCKY MOUNTAIN COAL.

By J. Blodget Britton and C. M. Cresson.

(*Read at a Meeting of the American Philosophical Society, Nov.* 6, 1874.)

The four coals from cast of the Rocky Mountains and on the line of the Union Pacific Railroad, exhibited at the meeting held on the 6th ult., I have since analyzed for metallurgical purposes, with the following results:

Carbon Coal, from the Mine at Carbon.

(*Sample consisted of several pieces, and weighed* 12 lbs.)

Water	12.50
Volatile combustible matter	35.47
Fixed carbon	44.96
Ash	7.07
	100.00

One hundred parts of the raw coal gave of coke..... 52.03

The coke was composed of

Carbon	86.42	
Ash	13.58	
	100.00	Including sulphur 1.03
		Phosphorus .....trace

Coal from Alury Mine.

(*Sample consisted of several pieces and fine stuff, and weighed* 21½ lbs.)

Water	12.95
Volatile combustible matter	32.54
Fixed carbon	44.56
Ash	9.95
	100.00

One hundred parts of the raw coal gave of coke..... 54.51

The coke was composed of

Carbon	81.75		
Ash	18.75		
	100.00	Including sulphur	.29
		Phosphorus	.04

Coal No. 3, from Mine at Rock Spring.

(*Sample consisted of a single piece, and weighed* 18½ lbs.)

Water	13.40
Volatile combustible matter	35.25
Fixed carbon	49.81
Ash	1.54
	100.00

One hundred parts of the raw coal gave of coke..... 51.35

The coke was composed of

Carbon	97.01		
Ash	2.99		
	100.00	Including sulphur	.63
		Phosphorus	.02

Coal from Excelsior Mine, at Rock Spring.

(*Sample consisted of several pieces and fine stuff, and weighed* 16½ lbs.)

Water	10.10
Volatile combustible matter	36.76
Fixed carbon	51.03
Ash	2.11
	100.00

One hundred parts of the raw coal gave of Coke..... 53.14

The coke was composed of

Carbon	96.03		
Ash	3.97		
	100.00	Including sulphur	.92
		Phosphorus	trace

The coals swelled very little during the coking. When powdered and heated they agglutinated. The cokes resemble in appearance the kind produced from the average bituminous coals of Western Pennsylvania.

A portion of the sample from Carbon Mine was subjected for an hour and a half to a temperature of 178° F., and lost in weight 5.72; subjected for one hour more to a temperature of 280° F., the loss was increased to 7.31; and again for two hours more to the same temperature, the whole loss was found to be 7.55. Another portion of the same sample was then subjected for three hours to a temperature of 500° F., and the loss was 9.55. The watery vapor was condensed in a cold glass tube, the tube was carefully weighed and then the water was evaporated; the tube when cold was weighed again, and from the loss the weight of water was ascertained. The coal was then weighed, and its loss was found to correspond very nearly with the weight of the water. A portion of the same coal was immediately put into another tube and subjected for a moment to a low red heat, when more water passed off and collected in the cold part of the tube; subjected for another moment to a little higher temperature, a dark brown oil passed off and condensed on the top, and ran down the sides of the tube in the space between the coal and water. The oil emitted a strong odor, the same as the oils produced by distillation from the brown friable lignites of Southern Arkansas and Texas. The other three coals produced water and oil in like manner at a low red heat.

These coals are not lignites, and I believe that if dried at a temperature of about 500° F., or a little above, will answer for puddling iron and the purposes of the blacksmith, and that the cokes will answer for producing pig iron in the blast furnace.

J. BLODGET BRITTON,
Iron Masters' Laboratory.

They were examined for steam and illuminating gas purposes by Dr. C. M. Cresson. The following is his report:

OFFICE AND LABORATORY,
No. 417 Walnut Street, Philadelphia.

Coals marked "Carbon Mine," "Excelsior," "Mine No. 3" and "Alury," have been examined as to their fitness for the production of steam, and suitability for producing illuminating gas, Pittsburgh (Pennsylvania Gas Coal) being used as the standard of comparison.

The following results have been obtained:

Coal.	*Pounds of Water evaporated by one pound of Coal.*	*Gas to the Pound of Coal when all of the Gas is worked off.*	*Value of Five Cubic Feet of Gas in Candles when all of the Gas is worked off.*	*Value of Five Cubic Ft. when the amount is limited to 4.4 Cubic Feet per Pound of Coal.*
Carbon Mine.....	13.42	5.17 Cu. Ft.	9.52	10.30
Excelsior	13.53	5.54 " "	11.80	12.00
Mine No. 3.....	12.65	6.06 " "	7.80	12.30
Alury	12.77	5.77 " "	6.90	9.
Penn. Gas Coal....	14.67	5.2 " "	12.	14.

The heating power of these coals compares favorably with that had from the majority of semi-bituminous and many bituminous coals. They shoul l be burned in boilers adapted for use with bituminous coals.

As gas coals, Excelsior and Mine No. 3 possess fair qualities. They yield a very large amount of gas, and with a little enrichment (either by the admixture of cannel or a small amount of oils) will prove serviceable to the gas-maker.

If these samples are from outcrop or from near the surface, it will most likely be found that the quality of the coal will improve, as it is obtained from a greater depth; so that without any limitation in the quantity of gas yielded, they will compare more favorably with the eastern bituminous coals for gas purposes. Respectfully,

CHARLES M. CRESSON, M. D.

SYNOPSIS OF THE VERTEBRATA OF THE MIOCENE OF CUMBERLAND COUNTY, NEW JERSEY.

By E. D. Cope.

(*Read before the American Philosophical Society, Feb. 5, 1875.*)

The marls of the Miocene period appear in a limited area in Southwestern New Jersey, chiefly in Cumberland County. Their mineral character is similar to that of the marls of the same age in the Southern Atlantic States, viz.: a calcareous clay containing small percentages of phosphate of lime and potash. In New Jersey its strata abound in shells, and Vertebrate remains are rather common. Timothy A. Conard, the father of our Marine Tertiary Geology, as early as 1832, in his "Fossil Shells of the Tertiary," called it the upper marine formation, and stated that it "first appears in New Jersey, southeast of Salem, and continues throughout all the States south of this." Professor Rogers, in his Geology of New Jersey, published in 1840, p. 293, calls the beds Tertiary, and remarks "though this proposition (of shells) might rather imply an Eocene date for the deposit .... while on the other hand all the species are either identical with those of the Miocene of Maryland and Virginia, or exhibit a close analogy of form." In a memoir read before the American Philosophical Society, and published in the volume of Transactions for 1837, p. 334 Prof. Rogers, assigns the corresponding beds in Eastern Virginia to the Miocene period. The evidence derived from the vertebrate fossils does not conflict with this view. A full account of the geology of the formation as it appears in New Jersey, is given by Prof. G. H. Cook, in his report of the Geological Survey of New Jersey, 1868.

ELASMOBRANCHII.

LAMNA ELEGANS.
LAMNA CUSPIDATA.
LAMNA DENTICULATA.
OXYRHINA XIPHODON.
OXYRHINA MINUTA.
OTODUS APPENDICULATUS.
CARCHARODON MEGALODON.
CARCHARODON ANGUSTIDENS.
HEMIPRISTIS SERRA.
ZYGAENA PRISCA.
GALEOCERDO ADUNCUS.
GALEOCERDO EGERTONII.
NOTIDANUS PRIMIGENIUS.
AETOBATIS SP.
MYLIOBATIS SP.
ZYGOBATIS SP.
PLINTHICUS STENODON, Cope, Proceed. Boston Soc. Nat. History, 1867, p. 316.
PRISTIS AMBLODON, Cope, ibidem, 312.

ACTINOTERI.

PHYLLODUS CURVIDENS, Marsh, Proceed. Amer. Assoc. Adv. Science, 1870, p. 229.

CROMMYODUS IRREGULARIS, Cope, Proceed. Amer. Philos. Society, 1869, p. 243; Proceed. Boston Soc. Nat. History, 1869, p. 311.

PHASGANODUS GENTRYI, Cope, sp. nov.

Represented by one of the long teeth of the anterior part of the jaws. It is slender and curved backward, and the anterior view presents a cutting edge fron the apex to the base; there is no cutting edge nor angle on the posterior face, unless it be at the apex, which is broken off in the specimen. On one side the cementum is smooth; on the other, and posteriorly, the crown is keeled-striate from the base to near the apex. Length preserved, .010; long diameter at base, .0022; do. near apex, .0020; short diameter at base, .0012. Dedicated to my friend Thomas C. Gentry, of Philadelphia, an acute observer of nature.

SPYRAENODUS SPECIOSUS, Leidy, *Sphyraena speciosa*, Leidy, Proceed. Acad. Nat. Sciences, 1856, p. 221.

SPHYRAENODUS SILOVIANUS, Cope, sp. nov.

Represented principally by a portion of the dentary bone, supporting five teeth, and containing alveoli for four others. The jaw is compressed and slightly curved and with smooth surface. The teeth are subequal, compressed, rather short and acute, and without roots; at their bases the alveolar borders are notched. Length of fragment, .020; depth at middle, .004; length of a tooth, .003; long diameter at base, .002.

REPTILIA.

TRIONYX LIMA, Cope, Ext. Batr. Rept. N. Amer., 1870, p. 153. Pl. vii. Fig. 14.

PUPPIGERUS GRANDÆVUS, Leidy, *Chelone grandæva*, Leidy, Proceed. Acad. Philadelphia, 1861, p. 203; *Puppigerus grandævus*, Cope, Ext. Baltr. Rept. N. A., 1870, p. 235.

THECACHAMPSA SERICODON, Cope, Proceed Acad. Phila., 1867, p. 143; Ext. Batr. Rept. N. Amer., 1870, p. 43, Pl. v. Fig. 8.

INCERTAE SEDIS.

AGABELUS PORCATUS, Cope, gen. et sp. nov.

Established on an osseous body which nearly resembles the elongate muzzle of a *Priscodelphinus* without teeth, but with the alveolar lines excavated into a deep groove on each side. The superior surface possesses a shallow median groove as in most delphinoid cetaceans, while the supposed palatal face is plane and sharply defined by the lateral grooves. The latter are bounded above by a thin overhanging border on each side, and their fundus is marked by a series of nutritious foramena of small size, apparently corresponding to the positions of teeth of other genera.

With this imperfect material it is impossible to decide positively on the character of this genus, but I suspect that it will be found to be allied to the sword-dolphins of the genus *Rhabdosteus*, Cope.

Char. Specif. The general form is depressed, and the outline tapers regularly to near the apex. The upper face presents two convexities, one on each side of the median groove, but towards the base these parts are not exactly symmetrical. There is a narrow bevel descending to the margin on each side. The grooves are wide and deep, anteriorly wider than the palatal rib which separates them, and opening outward as well as downwards. Bone moderately dense, surface not covered with the cementum and faintly longitudinally line-grooved. Total length of fragment, M. .065; width do. at base, transversely .012, vertically, .006; with palate at base .007; at broken extremity, .002; depth at do. .0035.

MAMMALIA.

SQUALODON ATLANTICUS, Leidy, Cope, Proceed. Academy, Philada., 1867, p. 153; *Macrophoca atlantica*, Leidy, *l. c.* 1856, p. 220.

ZARHACHIS VELOX, Cope, Proceed. Acad. Philadelphia, 1869 (March).

PRISCODELPHINUS HARLANI, Leidy, Proceed. Acad. Phila., 1851, p. 327.

PRISCODELPHINUS LACERTOSUS, Cope, *Delphinapterus lacertosus*, Cope, ibidem, 1868, p. 190.

PRISCODELPHINUS GRANDÆVUS, Leidy, ibidem, 1851, p. 327. *Tretosphys grandævus*, Cope, ibidem, 1869 (March).

PRISCODELPHINUS URAEUS, Cope, *Tretosphys uraeus*, Cope, 1869 (March).

The four preceding species may be regarded as congeneric for the present, as they are similar in the forms of the vertebræ, especially in

the lumbar diapophyses. A few years ago I defined a genus, based on several species from the Miocene of Maryland, in which the lumbar diapophyses are spiniform. Supposing the *Priscodelphinus harlani* of Leidy to possess the same character I retained the same generic name for the Maryland species. After an examination of considerable material from the New Jersey locality, including bones of *P. harlanii*, I have failed to observe a single species with the spinous processes alluded to. It thus becomes evident that *Priscodelphinus* must be retained for the species termed by me *Tretosphys*, while that for which I retained the name *Priscodelphinus* must receive a new one. For this I propose *Belosphys* with *B. spinosus*, Cope, as type, and *B. atropius*, *B. conradi* and *B. stenus* as species. At the same time I add that the presence of *Ixacanthus coelospondylus*, Cope, in the New Jersey Miocene mentioned in Cook's Geological Survey of New Jersey by the writer, is doubtful.

Total number of species, thirty-three.

ORIGIN OF THE LOWER SILURIAN LIMONITES OF YORK AND ADAMS COUNTIES.

By Persifor Frazer, Jr.

(*Read before the American Philosophical Society, March* 19, 1875.)

The three great deposits of Lower Silurian limestone which occur in this State, are: 1st. That of the Chester Valley which begins at Willow Grove, in Montgomery county, and terminates about a mile west of Minerstown, in Lancaster county; 2d. The great Lancaster and York county basin which, commencing about a mile northeast of Morgantown, crosses the Susquehanna River in two prongs, the longer (most northerly) of which terminates almost on Mason and Dixon's line in the southeast corner of Adams county; and 3d. The great valley, *par excellence*, which enters the State at Easton on the Delaware River, and passes into Maryland in a wide belt, which stretches fifteen miles east and the same distance west of Middleburg, Franklin county.

Accompanying all these limestone basins are belts of iron ore which crop out at tolerably uniform distances below their edges. In the still lower measures of the Silurian, and above the Potsdam sandstone, are other belts of ore entirely disconnected from the limestone ores.

In the first Report of the Geology of Pennsylvania (Vol. I, p. 218), it is stated of the Rathfon Ore Banks of Lancaster county, that in this, as in most of the other iron veins connected with the magnesian limestones,

the position of the ore is precisely at the junction of the limestone and slate. "It is indeed only a very ferruginous variety of the metamorphosed slate regularly stratified and intercalated with it."

Again, "west of the Gantner Ore Diggings," * * "the ore lies in decomposed sandy talco-micaceous slate between the sandstone and an outcrop of limestone south of it." And just beyond, "The Conewango Ore Bank lies at the junction of the Auroral limestone and the talco-micaceous slates of the primal series." In another place, the section of this limestone at Strickler's Run is given, commencing at the lowest number of the series:

1. Limestone, 150 feet.
2. Blue talcoid slate, 200 feet.
3. Limestone, 15 feet.
4. Dark-blue slate, 20 feet.
5. Limestone (?).
6. Bluish talcoid slate, 200 feet.
7. Limestone (?).

(Total 405 + feet).

Of the iron ores of York county, it is stated simply that a belt is traceable along the southern edge of the limestone towards Littlestown, but has been long neglected, owing probably to its containing a considerable portion of the oxide of manganese. All these statements agree in placing the limonites just beneath the Auroral limestone. The older ores seem not to be mentioned at all.

The ores of York county are of three kinds: 1st, pyritiferous and partly magnetic limonites; 2d, the limonites proper, which were the special objects of my investigation last summer; and 3d, the micaceous and magnetic ores of the Mesozoic sandstone. The first fact of importance with regard to the second of these kinds, is that (corroborated by Prof. Prime), they never occur far from the Auroral limestone, but always on its edges, thus skirting the entire basin (when not overlain by the Red Sandstone), and forming a line of ore wherever, within the limits of the basin, from folding and subsequent denudation, an edge of this Auroral limestone is exposed. 2d. They are *almost* always in the form of segregations in yellowish and bluish clay. 3d. Not only is each belt of ore made up of small pockets and nests lying without regularity in the decomposed slates constituting the clay, but in some cases the belt itself is capricious and appears to run out whenever the rock becomes less easily decomposable.

I should hesitate to ascribe the source of this iron supply to the minute crystals of pyrite which undoubtedly permeate some horizons of the great Calcareous deposit, both because their number and the porousness of the limestone as observed in connection with the ore,

seem to bear no relation to the latter. Besides, the supply of iron from such minute crystals in the limestone would be insufficient to produce the limonite beds. It seems much more probable that the source of the supply of iron were the pyrite crystals of the slates which, once towering high in the air, have been carried down by denudation and deposited in the Atlantic. Even these slates which are not so situated as to permit the percolation of water through them, exhibit a porous structure, the pores being filled with brown ochreous limonite, and this occurs to a considerable depth, and the slate merges by imperceptible degrees in a direction normal to the plane of bedding, first into completely metasomatized pseudomorphs of limonite after pyrite (but still retaining the form of the latter); then the same with a kernel of pyrite; then the pyrite itself, first with a shell and then with a mere stain of ferric hydrate; and finally the same slates are revealed porphyritic from the pyrite, but not at all decomposed.

The question as to the source of the iron in these limonite beds, is this: Does it come from the percolation and solution of its pyrite disseminated through the more recent limestone, or does it come from the decomposed pyrite in the slates of the same age? For it will hardly be disputed, that the main source of the supply consisted of pyrite, nor that the decomposition of the slates into clays was the means of providing the impermeable medium in which the iron solutions were caught and imprisoned. If the former hypothesis be the true one, we should expect to see an absence of limestone in the vicinity of the large deposits; for (granting for the moment that the limestone contains enough pyrites to account for the entire deposit (a fact which at least admits of some question), a percolation of water sufficient to oxidize the sulphur of these pyrite crystals and carry away enough iron to produce the beds, would entirely honey-comb and finally, both by solution and attrition, dissipate the limestone bed. But in and near some of the largest limonite beds we find the limestone scarcely weathered, and in few cases, if any, is it rendered ferruginous or even stained to any great degree by chalybeate waters. Indeed, the absence of the familiar iron stain from the calcareous member of this formation is so marked, that this point of difference from the adjacent members of the series cannot fail to arrest attention.

Again the uniformity of the occurrence of these limonite deposits on the skirts of the basin and the lower edge of the elevated limestones and their absence elsewhere, cannot but be the result of the law of their formation. Were these deposits derived from the pyrite disseminated through the limestone there would be no way of explaining the adherence to the rule when the strata were highly inclined or vertical, except by supposing that the ferruginous solution from the limestone found its way across the decomposing slate beds in a direction perpendicular to their planes of lamination—an hypothesis opposed to all experience. But this would not account for the absence of iron oxide on the remaining edges of the limestone itself, for even if we could accept the

flow of the waters through the bedding we should be at a loss to account for the absence of that flow along the planes of bedding. It is objected in short to the hypothesis which would derive the limonite beds from the disseminated pyrite in the overlying limestone. 1st. That the less the limestone actually *overlies*, cæteris paribus, the greater the extent of the limonite deposits. 2d. There is no appearance of wasting in the limestone commensurate with the effect produced, and not even the staining from chalybeate waters which must have accompanied such a genesis. 3d. Very similar deposits are found in regions widely remote from the limestone (thousands of feet of measures below it,—*i. e.*, Hofacker's, and the Cameron Iron Co.'s mine, &c.).

The facts which are most intractable according to the former hypothesis might have been predicted on the latter. A large portion of the slates underlying the Auroral limestones are pyritiferous. A specimen taken from a point on the Peach Bottom Railroad, about five miles southeast of York was selected rather than one nearer to the limestone basin, because in these latter the pyrite is distributed in crystals too minute to be easily counted, while probably not differing materially in the amount of iron contained. A slab of this slate $3\frac{1}{2} \times 2\frac{1}{2} \times \frac{3}{8}$ inches was examined to ascertain the number of prints of pyrite crystals which it contained. On the area of the surface $3\frac{1}{2} \times 2\frac{1}{2} = 8.75$ sq. inches there were counted 350 such pits visible to the naked eye.

A micrometric measurement of a large number of these pits gave all intermediate dimensions between $\frac{1}{16}$ and $\frac{1}{48}$ of an inch. Assuming the mean of the cubes of these dimensions or 0.000213 cubic inch as the average size of a crystal, we have 40 such crystals in 1 square inch, occupying 0.00851 cubic inch. In the specimen examined which was $\frac{3}{8}$ inch thick, there were nine layers distinctly visible to the naked eye. Each layer was therefore $\frac{1}{24}$ inch in thickness, and supposing only 0.00852 cubic inch of pyrite in each square inch of laminæ, we have $0.00852 \times 24 \times 12 \times 5 = 12.27$ cubic inches of pyrite in every square inch of area and 5 feet of thickness of these slates. One cubic inch of pyrite weighs 126.1 grains. In the above thickness and area of these slates there are then 1547.25 grains, or in each square foot of the same thickness 222803.57 grains = 31.81 lbs.

This would give us for every mile of outcrop and 1000 feet of arch above the present surface the enormous sum of 168,009,600 lbs. = 75,004 tons of 2240 lbs. But the metallic iron in this mass of slates one mile in length and five feet in thickness would weigh 47729.7 tons, and supposing it to be also oxidized, the anhydrous oxide would weigh 68185.2 tons and as limonite 79691.5 tons.

Assuming $\frac{1}{4}$ of this to be washed into the soil and $\frac{3}{4}$ to be left as earthy iron ochre in the pits originally filled by pyrite in the slates still in place and only partially decomposed,—which lie in juxtaposition to the ore; then every outcrop of these slates one mile long and *one foot* deep has contributed about 20 tons to the deposits. But the entire mass of the rocks

which were formerly above the present surface have been washed away, and with them their 47,730 tons of metallic iron, or their 79,691 tons of limonite (if all this iron was hydroxidized), for every 1000 feet of slope, 5 feet of thickness and 1 mile of outcrop. Added to the smaller contribution of the partially weathered slates at the surface, this gives the total of 79,711 tons of limonite per mile, which has been gradually carried down the dip and segregated among the clays. But these slates are of very great thickness—at least 100 times what has been assumed. Allowing, then, for all loss by transportation into the sea, and through breaks in the continuity of the clay beds to great depths under ground, and for combination with the silicates to form double salts, we still have more than enough to account for all the largest ore banks. It will be asked, why these deposits should bear so close a geographical relation to the limestone basins? An example taken from Feigley & Brillhart's bank in the Dunkard Valley, one mile east of Logansville, is interesting in this connection. Here is the southwest limit of the easterly portion of the small limestone trough which runs parallel with and south of the greater York county synclinal. About a quarter of a mile east of Brillhart's works there occurs a rock almost indistinguishable from the other slates but which contains ± 33 per cent. (?) of calcium carbonate.

This indicates either that these slates have been subjected to a long soaking with calcium bicarbonate or that the deposits of the carbonate of lime proceeded together with the mechanical deposition of the sediments which formed the slate bed.

In reference to the older limonite formations of Lancaster county, it is said (Vol. I, p. 183): "An interesting inquiry is here suggested as to what can have been the geological atmospheric condition which produced the remarkable percolation which carried down so large an amount of ore out of these ferruginous beds. Was it tepid rain charged with carbonic acid in an early Palæozoic period? Or could it have been a long filtration of surface waters such as now soak the earth? Or are we to surmise an action of internal steam issuing upwards through crevices in the strata in a period of crust movement and disturbance? I am inclined to the first conjecture."

Dr. Hunt in his essay on metalliferous deposits (XII, Chem. and Geol. Essays, Boston, 1875, p. 229), says: "The question has been asked me—Where are the evidences of the organic material which was required to produce the vast beds of iron ore found in the ancient crystalline rocks? I answer that the organic matter was in most cases entirely consumed in producing these great results, and that it was the large proportion of iron diffused in the soils and waters of those early times which not only rendered possible the accumulation of such great beds of ore, but oxidized and destroyed the organic matter, which in later ages appear in coals, lignites, pyroschists and bitumens. Some of the carbon * * is, however, still preserved in the form of graphite," &c.

With reference to the Ferric Sulphide or pyrite, the same author

ascribes its formation to the deoxidizing agency of decaying organic matters out of contact with air on soluble sulphate of lime and magnesia, giving rise, if carbonic acid be present, to Hydrogen Sulphide which "in some conditions not well understood contains two equivalents of sulphur to one of iron." He adds that he has observed that the ferrous sulphide or proto-sulphide of iron in presence of a per-salt of iron loses one-half of its iron, the rest being converted to Ferric Sulphide."

It seems at least a possible explanation for this more prominent determination of limonite along the edge of limestone, that by the oxidation of the pyrites of the slates an equivalent of sulphuric acid in addition to that necessary to form Ferric Sulphate has been produced. That this molecule of free sulphuric acid in its passage over the mica and chlorite slates has dissolved out part of their alkalies, especially soda. That this solution of sodium sulphate has mingled in the clay beds below with the solution of calcium bicarbonate, produced by the drainage of rain waters over the limestone beds, giving rise to sodium bicarbonate and calcium sulphate. That this sodium bicarbonate reacting on the Ferrous Sulphate has precipitated Hydro-Ferrous Carbonate which has been by oxidation rapidly converted to Ferric Hydrate, while the Ferric Sulphate has been immediately thrown down as hydrous oxide. This, be it repeated, is simply one of many explanations which may suggest themselves of the observed fact that the limonite deposits are more frequent and extensive in the neighborhood of limestone deposits.

But though the solutions from such basins may favor the deposition of this ore, they are not always necessary.

It has been incidentally stated that one proof that the supposed iron in limestones was not necessary for the formation of these limonite beds, is that very similar limonite beds are known to occur miles away from any known outcrop of limestone. Such are the beds referred to as the Hofacker, Cameron Co., Keeny Banks, &c., &c., which occur in the lower part of York county and the upper portion of Baltimore and Carroll counties, Maryland. The circumstances of occurrence alike in both cases are the pyritiferous character and the highly inclined strata. The former is much more coarsely porphyritic in the older beds so that the hydroxidation of the pyrites has not been so perfect, and the ore is much more red short than is the case close to the limestone. But the large amount of pyrites in the rocks, in all stages of transition to limonite, would seem to render the search for any other source of supply of iron unnecessary.

NOTES ON THE GEOLOGY OF WEST VIRGINIA.

No. II. *

By Jno. J. Stevenson.

Professor of Geology in the University of New York.

(*Read before the American Philosophical Society, February 5th*, 1875.)

During July and part of August, 1874, I made a reconnaissance of a portion of West Virginia lying between Rich Mountain and the Ohio River. In this area are included parts of Randolph, Upshur, Harrison, Lewis, Doddridge, Ritchie and Wood counties. To connect this work with that reported in my previous paper, I made some examinations in Taylor and Marion counties.

This whole region has suffered much from erosion, and its surface is a confused mass of hills and ravines apparently without system. In the eastern portion, that drained by the forks of the Monongahela River, the valleys are usually quite broad and the hills are rounded except in the vicinity of Rich Mountain, where, owing to the increasing dip, the slopes become quite sharp. In this drainage area the main streams flow across the dip, whence result the broad valleys and gentle slopes observed on Tygarts, Buckhannon, and the West Fork River. On the west side of the divide, separating the Monongahela from Hughes' River on the Little Kanawha, the conditions are different. There the streams flow, for the most part, with or opposed to the dip, so that one finds the country abrupt and the valleys narrow until he approaches the Ohio.

Between Rich Mountain and the Ohio the soil is not very rich, owing to the comparatively small quantity of limestone present. In portions of Randolph and Upshur counties, however, there is much rich land along the "bottoms," the alluvium being in a measure derived from the lower carboniferous rocks. The western portion of the area is very lean, as the soil has resulted simply from disintegration of the Upper Barren shales or sandstones, or in other localities from similar disintegration of the red argillaceous shales of the Lower Barren Group. It is said that in Doddridge, Ritchie and Wood counties, there is comparatively little land rich enough to yield forty bushels of corn per acre.

Over the greater portion of the area, the hills are covered by a dense growth of valuable timber, consisting chiefly of poplar (tulip-tree), red and other oaks, chestnut, beech and maple. The oak and poplar are quite valuable. At the west, much of this timber is floated to the Ohio by way of the Little Kanawha, not a little of it being sent down as single logs from the smaller tributaries. The magnificent timber on Rich Mountain will soon be available, as the obstructions in Buckhannon and Tygarts' Rivers are to be removed, so as to open the way to Grafton, where immense sawmills have been erected.

The availabilities of the country have not been fully tested, and for the

* No. I was published in Trans. A. P. S., Vol. XV, p. 15.

most part, it is thinly settled. Such of the inhabitants as have means, devote themselves to raising stock or wool, while the poorer classes are wasting their substance by cutting the fine timber into staves or shingles.

Throughout this whole region, evidences of drift are entirely wanting. The superficial deposits are thin except at the east, where the debris on the hills is so thick as to render satisfactory tracing of the strata almost impossible. Along the northwest Branch of the Baltimore and Ohio Railway, one finds frequent proof of the deepening of waterways, for on top of many hills, seventy-five to one hundred feet above the present streams, there occur fresh-water shells similar to those now living in the creeks.

Rich Mountain is the western slope of a great anticlinal ridge, whose eastern slope is known as Cheat Mountain. Between the two mountains is the anticlinal valley of Tygarts' River, whose scenery can hardly be excelled. Along the central line of this valley the dip of the strata is nearly 65° northwest and somewhat less southeast. Taking the Staunton pike westwardly, we find the dip diminishing, so that on top of Rich Mountain it is only 18°. Thence the decrease is very rapid, and at Roaring Creek the strata are almost horizontal. This condition continues for nearly twelve miles along the pike; after which the northwest dip is resumed, now 120 feet to the mile, and is retained until about two miles west from Buckhannon. There it is reversed, and we meet the anticlinal fold of Laurel Hill. The plane of this axis crosses the pike about three miles west from Weston, and there the dip is again toward the northwest at the rate of nearly 150 feet per mile. This rate continues for about twenty miles, beyond which the strata become almost horizontal. The Laurel Hill anticlinal crosses the railroad not far from Flemington, and the flattening of the strata begins near Long Run Station, thirty miles farther west.

About one-eighth of a mile east from Ellenboro' and forty-five miles west from Clarksburg, a sharp fault occurs, on whose eastern side the rocks dip almost due east at an angle of 26°, while on the western side the strata are horizontal. The exact line of fault is not exposed, and there is an interval of seventy feet concealed between the points of observation. The approximate horizontality continues westward to within a mile of Petroleum, where the dip becomes eastward and rapidly increases, followed west, until just west from that station it becomes 36°. From this point almost to Laurel Junction somewhat more than one mile, the dip is very confused, but a shattered anticlinal can be traced, the rocks meanwhile dipping east or west, as the case may be, at from one to five degrees. Near Laurel Junction the dip becomes five, ten, twenty, forty or even seventy-five degrees westward. In the cut immediately west from that station the rate decreases to five degrees within a space of six feet horizontally, and soon afterwards falls to only ten feet per mile. Beyond this to the Ohio the rocks remain almost horizontal.

The section obtained in passing from Rich Mountain to the Ohio embraces the whole of the Upper Carboniferous as found in West Virginia, and, if begun on the east slope of the mountain, includes also a very large portion of the Lower Carboniferous. The anticlinal valley of Tygarts' River is cut out of the Lower Carboniferous series, which is well exposed on each wall to the crests of the mountains. On top of Rich Mountain we find the Great Conglomerate forming the crest throughout Randolph county. On the western slope of the ridge are the Lower Coals, which pass under the surface before reaching the Buckhannon River in Upshur county. The Lower Barren Group is well exposed toward the foot of the mountain near Roaring Creek, and thence westward in the bluffs for nearly forty miles; but, owing to the flattening of the dip near Roaring Creek, it is the surface series for only a few miles in the area examined. Northward from the Baltimore and Ohio Railroad, or, better perhaps, at the State line, the Upper Coal Group finds its eastern outcrop several miles from Laurel Hill, but followed southward this outcrop is seen approaching the crest of the axis until near the railroad it crosses it. Along our southern line the fold becomes very gentle, so that the Pittsburg crosses its crest and has its outcrop nearly twenty-five miles east from it. The eastern boundary of the group is very tortuous. The Upper Coals extend westward almost to the line of the Ellenboro' fault, where the Lower Barren Group is thrust up. This continues to the especially disturbed area known as the "Oil-break," in which the Lower Coal Group is exposed. Beyond the "break" to the Ohio River the only rocks exposed are those of the Lower Barren. The region lying west from the Ellenboro' fault will be described separately.

The Upper Barren Group is cut off by the Ellenboro' fault, but eastward from that for nearly twenty miles its rocks are those covering the surface, those of the Upper Coal Group being found only in the deeper ravines.

The Coal Measures.

In this paper the terms, Upper Barren, Upper Coal, Lower Barren, and Lower Coal, as designations of the several groups into which the Coal Measures are naturally divided, are used in precisely the same sense as in my previous paper.

Upper Barren Group. This group, which includes all the rocks above the *Waynesburg Coal*, covers a large extent of territory, whose western line is the Ellenboro' fault. The eastern outcrop is an ill-defined line, passing a little west from Troy, in Gilmer county northward, and coinciding almost with the western line of Lewis county. It crosses the Northwestern Railroad near Wolfe's Summit, eight miles from Clarksburg, and running irregularly northeast, reaches the Baltimore and Ohio Railroad about three miles north from Fairmont, passing finally into Pennsylvania nearly four miles west from the Monongahela River.

The northwestern boundary in West Virginia is a line passing from the

Pennsylvania border near the junction of Ohio and Marshall counties, West Virginia, to a little below Moundsville, on the Ohio River. This is the overlying group in Doddridge, Tyler and Wetzel counties, as well as in the eastern half of Ritchie and the western portions of Monongalia, Marion, Harrison, Lewis and Gilmer counties.

The sudden cutting off of this group by the Ellenboro' fault and the consequent wearing away of the rocks by erosion prevent us from obtaining as full a section along this line as may be found farther north. The succession as observed here is as follows :

	Ft.	*In.*	
1. Sandstones and shales.....	400		
2. Black shale.....	2′		
3. *Coal* "Brownsville".....	3′		
4. Shale.....	20′		Interval, 38 ft. to 28 ft.
5. Sandstone.....	5–15		
6. Shale.....	3		
7. *Coal*.....		2	
8. Shale.....	20		Interval, 75 ft.
9. Sandstone and some shale....	55		

The total thickness of the group as here exposed is only five hundred and twenty feet. For comparison, I present a condensed form of the excellent section worked out by Mr. I. C. White,* in southwestern Pennsylvania and northwestern West Virginia :

	Ft.	*In.*	
1. Sandstones and shales,.....	300		491½ ft.
2. Limestone.....	1	6	
3. Sandstone.....	190		
4. *Coal*.....	1	6	
5. Sandstone.....	95		Interval, 95 ft.
6. *Coal*.....	2		
7. Shale and sandstone.....	85		Interval, 128 ft.
8. Limestone.....	3		
9. Shale.....	40		
10. *Coal*.....	1	4	
11. Shale.....	10		Interval, 52 ft.
12. Limestone.....	2		
13. Shale.....	40		
14. *Coal* "Brownsville"	2–3	6	
15. Shale.....	20		Interval, 20 ft.
16. *Coal*.....	1		
17. Shale.....	15		Interval, 60–65 ft.
18. Sandstone.....	45–50		

In this section the total thickness is eight hundred and sixty feet. It

* Annals Lyceum of Nat. Hist., Vol. XI. p. 46.

will be seen, however, that in my section the strata reach far enough up to include a portion of No. 3, in Mr. White's section, so that sufficient is found in the south to afford material for comparison of conditions in the two areas. It is noteworthy that the interval between the *Waynesburg* and the *Brownsville* is much greater in the southern than the northern section.

No. 1 of the section is entirely free from limestone, and consists of compact sandstones and loose shales. At the east, the sandstones greatly preponderate, and are very coarse in grain. Westward they diminish in quantity and are replaced by the shales. These are reddish gray to yellow and usually quite fissile. The whole series is finely exposed along the Northwestern pike, about four miles west from Salem, where the road descends a long steep hill and is merely a shelf, cut out of these rocks. Near Cherry Camp, thirteen miles west from Clarksburg, the base of the series is a bright yellow fissile shale, twenty feet thick, containing many crushed specimens of an *aviculopecten*. This shale is not persistent, being wanting at all exposures examined farther to the west. The other strata seem to be entirely free from fossils.

Along the Northwestern Railroad, the *Brownsville** coal is first seen at the east end of Brandy Gap Tunnel, ten miles west from Clarksburg. There it was worked formerly, but the banks have been long deserted and no measurement can be made. At the west end of the tunnel the coal is seen about twenty feet above the track and nearly three feet thick, Near Cherry Camp, one mile beyond, it has been worked in the creek bank by stripping. It shows there

Shale, 2 ft.; *Coal*, 9 in.; Bony Coal, 5 in.; *Coal*, 14–16 in.; total, 2 ft. 6 in.

The shale is full of vegetable impressions, some of which are very fine. If this shale could be reached farther in the bank, where it has not been exposed to the action of the weather, the locality would no doubt yield some excellent material to the palæo-botanist. The coal is said to be of very fair quality. Some taken from the same bed where it lies exposed in the stream, about one-fourth of a mile farther west, is said to have been very good.

The next exposure was found on the Northwestern pike, somewhat more than five miles west from Salem. The bed is there more complex than at Cherry Camp, and shows the following section:

Coal, 9 in.; Shale, 2 ft.; Bituminous shale, 1 ft.; Clay, 3 in.; *Coal*, 1 ft. to 1 ft. 6 in.

The sandstone rests directly on the coal. The bituminous shale contains many thin plates of coal and is so carbonaceous throughout that it will burn, though poorly. The coal is said to be quite good, and is mined by stripping. Near the railroad crossing, two miles east from Smithton, this bed was formerly worked. At Smithton its outcrop is

* So named by Mr. White, from its importance, near Brownsville, Monongalia county, West Virginia.

seen one hundred and fifteen feet above the *Waynesburg*, and near West Union it was observed in a railroad cutting, where it appears to be about one foot thick and single.

Near Pennsboro' an old opening is seen twenty feet below the level of the railroad. We there find the following section:

Sandstone,—; Shale, 10 ft.; *Coal*, 1 ft. 10 in.; Compact clay, 3–6 in.; *Coal*, 8 in.

The overlying shale is argillaceous below, but becomes arenaceous above and passes gradually into sandstone. The rocks are well exposed in the vicinity for nearly two hundred and fifty feet above the bed and are wholly sandstone and arenaceous shale. The coal seems to be quite good and must contain very little pyrites. The bank has been deserted for nearly twenty years, yet fragments lying on the dump are as sound and fresh-looking as though they had been thrown out within two or three days. The same bed is mined somewhat on the other side of the railroad. The coal is compact, open-burning, and leaves a pulverulent ash, quite bulky but not heavy. The bed can be traced in the vicinity of the railroad almost to Ellenboro'. The blossom is seen near the junction of the Northwestern pike and the Harrisville road. Near Harrisville its place is shown by a line of springs. On the Staunton pike it was seen only near Smithville, in Ritchie county, where it is one foot thick.

The small coal, No. 7, was observed only in the deep cut at the east end of Brandy Gap tunnel.

The shale underlying the *Brownsville* coal is variable in character and thickness. Occasionally the whole mass for thirty-five feet is argillaceous, blue to gray or drab, and quite thinly laminated. At other times, the whole interval between the *Brownsville* and the *Waynesburg* is occupied by a coarse sandstone.

The Waynesburg sandstone, No. 9, is a well marked and very persistent member of the series. It is ordinarily a compact and fine-grained sandstone, and at no place along the railroad is it at all conglomerate. Near Brandy Gap tunnel, where it has been largely quarried by the railroad company, its lower portion is somewhat flaggy. At Long Run, Smithton and West Union, it stands out in cliffs upon the hill sides, and is compact throughout. On the Staunton pike, it may be seen just west from Troy, where it is somewhat coarser than at the localities just mentioned.

Upper Coal Group. Under this name are included all that series of rocks beginning with the *Pittsburg* and ending with the *Waynesburg* coal. Along the Northwestern Railroad the group is well exposed from Clarksburg west. The general section is approximately as follows:

	Ft.	In.	
1. *Waynesburg Coal*	4		
2. Shale	8′		
3. Limestone and shale	6		
4. Argillaceous shale	20		
5. Limestone	1	6	
6. Arenaceous shale	30		Interval, 132 ft.
7. Limestone and shale	7		
8. Variegated shale	8		
9. Dark shale	6		
10. Sandstone	40		
11. Shale	6		
12. *Sewickly Coal*	2–3		
13. Shale	41		Interval, 41 ft.
14. *Redstone Coal*	3–3		
15. Fire-clay	2		
16. Limestone and shale	8		Interval, 20 ft.
17. Shale	10′		
18. *Pittsburg Coal*	6–9		

The interval between the *Waynesburg* and the *Sewickly* is very much smaller than in the northern portion of the State, where it varies from one hundred and seventy-five to two hundred feet, averaging about one hundred and eighty feet. Near Morgantown, this interval is one hundred and eighty, at Fairmont almost the same,* at Clarksburg one hundred and sixty, and ten miles west from Clarksburg, as given in the section above. The interval seems to decrease in this direction. Were this evidence absent, the character of the bed itself would leave no room for doubt respecting its identity with the *Waynesburg*.

No satisfactory exposures of this coal were observed except near the railroad. Its blossom is seen on the north side of the railroad near Clarksburg, at one hundred and sixty feet above the *Sewickly*. It is worked slightly at about nine miles west from Clarksburg, where it shows four feet of coal, divided nearly midway by a clay parting one foot thick. From this point westward, it was not seen until within two or three miles of Smithton, where there have been numerous openings, nearly all of them now deserted. At all of these, the bed is overlaid by twelve feet of dark argillaceous shale, containing vegetable impressions and holding midway, a layer of calcareous iron ore. At Smithton, the coal is worked by Mr. Smith, at whose bank the following structure is shown :

Shale, with vegetable impressions, 4 ft.; *Coal*, 2 ft. 2 in.; Clay, 3 in.; *Coal*, 2 in.; Cannel, 3 in.; Shale, dark-gray, fissile, 8 ft.; *Coal*, 1 ft. 6 in.

The coal is not very good, owing to the considerable proportion of sulphur. The bottom layer yields the best fuel, but as it is mined by strip-

* The Sewickly has not been seen at Fairmont, and this calculation is based on the relation of the Waynesburg to the Redstone.

ping in the run, the superiority may be owing entirely to removal of the pyrites by the water. The same bed is mined somewhat extensively at West Union, where one finds

Shale, 2 to 8 ft.; *Coal*, Cannel, 3 in.; Clay, 2 in.; *Coal*, 31 in.; Clay, 4–11 in.; *Coal*, 6 in.; Fire-clay, 3 ft.; Shale, to road, 7 ft.

The overlying shale is drab or slate-colored, quite fissile, and contains much nodular iron ore. It exhibits vast numbers of vegetable impressions, chiefly *Neuropteris*, *Cyclopteris*, *Pecopteris* and *Sphenophyllum*. Many of these are beautifully defined and equal those from the same horizon in Monongalia county. This shale varies in thickness at the expense of the sandstone above it. The fire-clay underlying the coal passes gradually into ferruginous, slightly arenaceous shales, below which, some limestone is seen farther up the stream. The upper parting in the bed occasionally shows leaf-prints. The lower parting is variable in thickness, and sometimes holds two sheets of coal, each one inch thick. The main coal is very hard, evidently open-burning and bears much resemblance to semi-cannel. It is said to be an excellent fuel. Though showing but little pyrites, when freshly mined, it becomes streaked with copperas when exposed to the weather. In this vicinity the bed is cut by numerous vertical seams of drab clay, which are quite distinct in the solid coal.

Along the Staunton pike this bed is much degraded. Several openings have been made upon it between Smithville and Troy, but it nowhere exceeds two feet. At a short distance east from Harrisville, in Ritchie county, it is found varying from six to eighteen inches in thickness.

Northward from the railroad this coal steadily increases in thickness until near the State line it averages more than eight feet, varying from eight to eleven. It is rarely single, usually double, and frequently triple.

The rocks occupying the interval between the *Waynesburg* and the *Sewickly*, show variations which deserve some consideration. Near the State line on the Monongahela River we find here, fifty-six feet of limestone, and at Wheeling there is one mass of limestone and calcareous shale, fully one hundred feet thick. At both localities much of the limestone is compact and quite pure. Along the Northwestern pike and the railroad, not more than sixteen or twenty feet of limestone can be found, and most of this is so poor that it ought rather to be called a compact calcareous shale. Still farther south, along the Staunton and Parksburg pike, not one foot of limestone was observed in this interval. From the northern portion of the State to the railroad, the limestone diminishes and gives place to shale, but from that line southward the shale apparently disappears, and sandstones appear instead. Along the railroad the limestones were seen near Wolfe's Summit, near Smithton and West Union. Traces of them occur east from Harrisville.

The *Sewickly coal* was identified at only two localities. At Clarksburg,

it occurs two feet six inches thick, and seventy feet above the Pittsburg. No attempt has been made to ascertain its value. On Wolfe's Summit, eight miles west from Clarksburg, the coal is only two inches thick. This bed seems to have as little persistence as the coals of the Barren Group, when traced southwardly. It has not been found at Fairmont, in Marion county.* No traces of it occur along the Staunton pike, in Gilmer county, and I cannot speak with certainty respecting its presence in either Lewis or Upshur county. It is, however, by no means improbable that the small coal above the Pittsburg in the latter county, is the Sewickly, and not the Redstone.

The interval between the *Sewickly* and the *Redstone* is entirely free from limestone. It is occupied by shale, none of which is calcareous. At Wheeling this space is filled with limestone, and on the Monongahela River near the State line, it contains thirty-one feet of limestone. On the Staunton pike the shales are replaced by flaggy sandstones.

The *Redstone* is a wide-spread and persistent coal, though rarely of economical value in West Virginia. At Fairmont, in Marion county, it is three feet thick and of good quality, but is not mined. Between that town and Clarksburg, its blossom is frequently seen in the roadside, and at the latter place it is six inches thick at the outcrop. At Wilsonburg, four miles west from Clarksburg, it is barely one foot thick, while at Coketon, two miles beyond, it is four feet, and of excellent quality. Where last seen toward the west, at Wolfe's Summit, it is only three inches thick. A thin coal, varying from one to two feet, is found above the *Pittsburg* in Upshur county. Whether or not this is the Redstone, the material in my possession is not sufficient to decide.

The rocks occupying the interval between the *Redstone* and the *Pittsburg* are subject to great variations in character and thickness. At Fairmont the interval is eighty feet, at Pruntytown, seventy-five, at Bridgeport, sixty-five, and at Weston, somewhat less. At all of these localities which lie along a nearly northeast and southwest line, the interval is occupied by sandstone and shale at the base, and limestone on top. Westward from such a line passing through Morgantown, Fairmont, Bridgeport and Weston, the distance between the coals rapidly diminishes. At Clarksburg, it is twenty-five feet, occupied by shale or sandstone; at Wilsonburg, it is the same, filled with argillaceous shale; at Coketon, it is twenty-eight feet; while at Wolfe's Summit, it is twenty feet, the rocks being shale and limestone. A similar condition exists in the vicinity of Morgantown, as stated in my previous paper.

The limestone disappears altogether before reaching the Staunton pike, so that with the exception of a few scattered nodules no limestone occurs among the strata of this group along that line.

* In my previous paper, I stated that it occurred at Fairmont. I had misunderstood the statement made to me by Ex-Governor Pierpoint, respecting the coals of that vicinity.

Pittsburg Coal. The eastern limit of this bed aside from small outlying areas, is marked by a line beginning near Cheat River, on the Pennsylvania border, and extending west of south to Fairmont, and crossing the Tygarts' Valley River, a little above that town. Thence irregularly to Pruntytown, where it turns east by south to Flemington. From this point it follows a south-southeast course, almost to Tygarts' River, thence southward, crossing the Buckhannon River near the Upshur county line. There it again turns east by south, and so continues almost to the middle fork of that river, when the course changes to southwest, and so remains to the line between Upshur and Lewis counties. From this locality to where the bed crosses Pocatalico Creek near the Great Kanawha River, I have not followed it. The extreme eastern exposure occurs in Upshur county, about five miles east from Buckhannon, on the Staunton pike.

The extreme western line of exposure begins at the Pennsylvania line, nearly two miles west from Monongahela River, crosses that river about a mile below Fairmont. It lies a little west from the West Fork River, crossing Harrison county from Shinnston to Wolfe's Summit, on the Northwestern Railroad. Thence it runs southwestward through Lewis county, reaching Gilmer, near Troy, on the Staunton pike, and crossing the Little Kanawha, just below Glenville.

Owing to the abruptness of the Laurel Hill anticlinal, the area in which this bed is available is very narrow at the north, hardly more than six or seven miles wide. Southward the anticlinal becomes gentler and this area rapidly increases in width until along the Staunton pike the coal is available for a distance of nearly forty miles. The bed attains its greatest thickness toward the north, and diminishes toward the south and southeast.

In Monongalia county, this bed is double, except where overlaid by sandstone. This characteristic prevails in Pennsylvania and Ohio, as well as in the Ohio Panhandle of West Virginia. But southward from Fairmont this division is rarely marked by a distinct clay parting, though the difference between the upper and lower benches sufficiently proves that the bed is still double. Occasionally, however, as at Shinnston and near the tunnel east from Clarksburg a well-defined clay parting separates the two branches.

In Upsher county the openings are quite numerous in the vicinity of Buckhannon, and the *Pittsburg* is the only source of supply for a large area. The coal varies from three feet nine inches to four feet, and is said to be of very fair quality. Though the parting is exceedingly thin, the upper and the lower benches are very distinct, the former being hard and leaving a bulky red ash, the latter being soft and clean, yielding a white ash. In the northern part of the county, very near the Barbour county line, the coal is mined on the Westfall property, where it shows

Coal, 32 in.; Parting, ⅛ in.; *Coal*, 34 in.; total, 5 ft. 6 in.

Though very thin, the parting is persistent. The upper bench is quite

hard and contains a good deal of bony semi-cannel, but the proportion of good clean coal is quite large. It burns well, but leaves a bulky ash. The lower bench is a remarkably clean coal. Layers of apparently pure bitumen are seen, two to four inches thick, structureless, showing no lamination, and breaking with beautifully conchoidal fracture. At this opening the coal is exceedingly good, and shows no pyrites under a glass. It does not disintegrate upon exposure, nor does it exhibit streaks of copperas. Near this opening is the Connolly bank. At the time when it was examined, this had not been fully opened, and only five feet of coal were exposed. The appearance is somewhat strange, as no division into benches can be made out, and the bed seems to be homogeneous. The coal is pure throughout, and evidently very rich in volatile combustible matter. The coal from these banks would yield an excellent coke, and would be exceedingly profitable in gas-making.

In Lewis county, this bed is easily accessible, and it is worked quite extensively to supply local demand. Openings were examined only along the Staunton road, though many were seen on the West Fork River, both above and below Weston. In the central portion of the county the thickness varies from four feet six inches to nearly eight feet, increasing northward. The bed is apparently single, but close examination shows the existence of two benches, the upper being invariably harder and less pure than the lower. Owing to the thinness of this bed in the southern portion of the county, many persons do not believe it to be the *Pittsburg*, but refer to that horizon the *Upper Freeport*, which appears to be quite thick in the river near Weston.

In Gilmer county the coal is mined near Glenville, where it is from four to five feet thick. About one mile east from Troy, an opening shows the following section :

Shale, gray, 8 ft.; *Coal*, 29 in.; Parting, ½ in.; *Coal*, 38 in.; total, 5 ft. 7½ in.

The coal is very good and shows but little pyrites. The upper bench is quite compact and leaves a red ash. The lower is softer and burns more readily, leaving a not bulky, white ash. About one-half mile farther east is a bank in which the coal is seven feet at the mouth, and farther in is said to reach nine feet. Near the county line the coal is again opened, but there it is barely five feet thick.

In Harrison county, openings are quite numerous along the railroad, and the coal is mined extensively for shipment. Notwithstanding the presence of a good deal of pyrites, it finds a ready market as a gas coal.

At Clarksburg, one of the most extensive openings shows the structure of the bed as follows :

Coal, 3 ft. 6 in.; Parting, ⅛ in.; *Coal*, 5 ft. 4 in.; total, 8 ft. 10 in.

Excepting four inches at the bottom, the lower bench is a fine clean

coal, while the upper bench is somewhat bony, quite hard and bears much resemblance to the ordinary roof coal of this bed as seen farther north and northwest. The parting varies from $\frac{1}{8}$ in. to $1\frac{1}{2}$ in. and is persistent in all the openings in this vicinity. In the lower bench there occur three thin partings, twelve, fifteen and eighteen inches respectively from the bottom, between which is the soft coal, the "bearing-in bench" of the miner. The character of this lower bench is precisely the same with that of the lower division of the Pittsburg throughout northern Ohio. Some pyrites occur here, but the quantity is not great. The upper bench contains a layer of "slate," four inches thick and irregular in its place. On the north side of the railroad the seam is much troubled by sandstone horsebacks, some of which are quite extensive, having been traced for more than half a mile across the entries of different openings. In one bank such a horseback was found, eight feet wide. It was followed for five hundred yards, but showed no sign of thinning out. Along the whole distance, it has not only cut out the coal, but has also trenched the fire-clay and sandstone below. It is said to be more compact than the overlying sandstone.

At Wilsonburg, four miles west from Clarksburg, the coal shows an average thickness of seven feet six inches, but near the mouth of the main entry increases to eight feet four inches. The parting is black clay, and varies from $\frac{1}{8}$ to 2 in. The coal at the base for one foot is very poor and hardly marketable, but the remainder of the lower bench is a very fine coal, containing, it is true, much nodular pyrites; but this is easily separated. There are no well-defined minor partings in this bench. The upper bench is quite hard and contains much splint coal. It is said to be quite as good for gas-making as the lower portion is, so that all parts of the bed are shipped together, the single foot at the base excepted, as that is too sulphurous.

At Coketon, the bed varies from five to seven feet. For three inches at the bottom the coal is very bad, but the whole bed above is taken out for shipment. The upper bench is heavy, compact and leaves much ash. The parting is one inch thick and consists of hard carbonaceous clay. Pyrites occur plentifully throughout the bed. but, being in nodules, is readily removed. The roof is a slickensided clay.

Where the bed disappears, near Wolfe's Summit, it is six feet thick and roofed with ten feet of argillaceous shale. East from Clarksburg, it is mined at Bridgeport and several other localities, but only to supply local demand. Numerous banks are worked in a small way along the West Fork River, and on the road to Shinnston, in this county. They show no material difference from those already described.

In Taylor county, openings were seen near Pruntytown and Flemington, in each case near the eastern outcrop of the coal. At Pruntytown, the bed is single and nearly eight feet thick. Above it is a dull reddish-gray shale, on which rests a massive sandstone. The coal, for the most part is somewhat inferior here, as the roof is very thin and usually not

sound. At Flemington the thickness is eight feet. There are no distinct partings, and the roof is a shaly sandstone, which occasionally forms a troublesome horseback. The coal from the banks here is said to be very good and to command a ready market for use in gas-making.

LOWER BARREN GROUP. It will be remembered that in the section given in my former paper, eight strata of limestone, having in all a maximum thickness of thirty feet, were represented as belonging to this group. These disappear southwardly, so that at Clarksburg only two remain, one underlying the *Pittsburg* coal, and the other about one hundred feet below it. Still farther south, in Lewis county, we find that only the upper one holds out, and that disappears long before reaching the Great Kanawha River. Even the fossiliferous limestone, which, in the Ohio Reports, I have named the *Crinoidal Limestone*, thins out finally before reaching the Northwestern Branch of the Baltimore and Ohio Railroad, though it is persistent in Ohio, Pennsylvania and northern West Virginia. The fossiliferous shales accompanying this limestone were traced to near Pruntytown, in Taylor county, beyond which, southward, they were not seen. Not far from Pruntytown, they yield beautiful specimens of *Productus prattenianus*, *Nucula ventricosa*, *Nucula* (?) *anodontoides*, *Yoldia carbonaria*, *Yoldia stevensoni*, *Edmondia aspenwalensis*, *Pleurotomaria* (?) *tumida* and *Bellerophon mcekianus*.

Southward to the railroad and east from the Laurel Hill axis, the shales increase greatly, but farther toward the south and especially along the axial line they are replaced by sandstone, so that on the Staunton pike, where the whole section is fully exposed for three hundred feet below the *Pittsburg* coal, the only rocks are sandstones. East from the axis the shales predominate, and for the most part are of a deep brick-red color. The same color characterizes them in the disturbed region at the west.

In Upshur and Randolph counties, between Buckhannon and Beverly, the Lower Barren Group seems to contain no coal, but in the vicinity of the former village, there is a small seam about forty feet below the *Pittsburg*. Between Buckhannon and Clarksburg another is seen about one hundred feet below that coal, and it occurs also at the latter place.

The thickness of this group shows little variation along the eastern border, and is not far from four hundred feet.

LOWER COAL GROUP. In Upshur and Randolph counties, it is impossible to procure a detailed section of this group without the expenditure of very much more time than was at my disposal. The whole country is deeply buried under debris, and connected exposures are rare. The rapid and somewhat irregular increase of dip near Rich Mountain, and the long stretches of "concealed," along the roads and streams render the building of a section exceedingly difficult. It is, however, sufficiently evident that this group, barely two hundred feet thick, near the Pennsylvania line, has rapidly developed so as to be in these counties

scarcely less thick than on the Great Kanawha River, where it is nearly nine hundred feet from the Conglomerate to the top of the Mahoning Sandstone. The following partial section, beginning with the Mahoning Sandstone, is said to have been obtained in a salt well bored on Buckhannon River:

1.	Rock	60 ft.
2.	*Coal*	15 ft.
3.	Shale	32 ft.
4.	Sandstone	40 ft.
5.	*Coal*	4 ft.
6.	Rock	160 ft.
7.	*Coal*	4 ft.
8.	Sandstone	40 ft.
9.	*Coal*	3 ft.
10.	Sandstone	120 ft.
	Total	478 ft.

The boring clearly stopped far short of the base as it did not reach the large and very persistent coal bed resting on the Conglomerate. As nearly as can be determined, the thickness of the whole group is not far from seven hundred feet.

No. 1 of the section, the Mahoning Sandstone, is ordinarily separated from the underlying coal by from six to ten feet of shale. It is a coarse sandstone, with numerous lines of pebbles, arranged parallel to the general plane of bedding. Some portions show extensive cross-bedding, and occasionally the rock is a coarse conglomerate. It is of uneven texture, and weathers into irregular cavities. Rude casts of vegetable stems are of common occurrence, and a thin coal is sometimes found about forty feet from the base.

No. 2 is the *Upper Freeport Coal.* Its changes in Upshur, Randolph and Barbour counties are very interesting. East from Buckhannon, on the Beverly road, it is first seen at the Sand Run crossing, in a deserted opening. The shale above it is dark, fissile, and about seven feet thick. Above this is the Mahoning Sandstone. The first satisfactory exposure is on Roaring Creek, at the foot of Rich Mountain, where the coal is worked and shows the following section:

		Ft.	*In.*
1.	Shale, drab, argillaceous	10	
2.	*Coal*		4
3.	Shale, dark, argillaceous	2	4
4.	*Coal*		10
5.	Clay, carbonaceous		1
6.	*Coal*		10
7.	Clay		¼
8.	*Coal*		9

	Ft.	In.
9. Clay		¼
10. *Coal*, semi-cannel	1	1
11. Clay		½
12. *Coal*, mostly semi-cannel	3	2
13. Clay, slickensided		4
14. *Coal*	1	9
15. Shale, drab		4
16. *Coal*, poor, seen	1	11
Total		

Of this section, the portion from No. 4 to No. 14, inclusive, yields a coal, fairly good, but of very uneven quality. It is a good fuel, and carelessly examined, appears to be quite clean. Under a glass it shows many minute crystals of pyrites, and when exposed to the weather, soon becomes streaked with copperas, so that its commercial value is at least doubtful. On Sand Run, several miles south from the crossing of the Beverly road, a remarkable expansion of the bed is exposed in the bank of the stream. The section is as follows:

	Ft.	In.
1. Bituminous shale	5	
2. *Coal*		7
3. *Cannel*, poor	2	6
4. Shale, slightly carbonaceous	4	
5. *Coal*, slaty	1	10
6. Shale, slightly carbonaceous	1	3
7. *Coal*, partly cannel	2	2
8. Clay, drab		8
9. *Coal*, bony		6
10. Clay		8
11. *Coal*, slaty	1	1
12. Clay, with streaks of *Coal*	1	2
Total	21 ft.	6 in.

In all this, the only coal which is fit for any purpose is No. 7, and even that is good for fuel only in case nothing else can be had. Yet this enormous mass of bituminous shale and bad coal has aroused great expectations throughout Upshur county. Its vastness, as reported on by a voluntary committee of the Legislature, is said to have caused a number of the legislators to look with favor upon Buckhannon as the site for the State Capital. The prevailing opinion respecting this bed is that its value is incalculable, whereas it is utterly worthless. Passing over to Grassy Run, another tributary to Buckhannon River, we find this bed mined on the property of Mr. G. Marple. Only a portion is exposed, giving the following section:

	Ft.	In.
1. Arenaceous shale	4	
2. Bony *Coal*		8
3. Parting		½
4. *Coal*		11
5. Clay parting		½
6. Bony *Coal*		6
7. Slate		11
8. Bony *Coal*	1	4

The coal from this bank is not very highly esteemed. About a mile farther down the run, an exposure in a bluff is as follows:

	Ft.	In.
1. *Cannel*, very poor	4	
2. *Coal*, bony	1	11
3. Clay, slickensided	2	2
4. *Coal*, semi-cannel		8
5. Shale, carbonaceous		3
6. Sandstone		3½
7. *Coal*		4
8. *Cannel*, poor	1	1
9. *Coal*, slaty		11
10. *Coal*, good	1	4
11. Clay		9
12. *Coal*, bony		4
13. Clay		6
14. *Coal*		5
15. Shale, drab		8
16. *Coal*	1	6
17. Clay, slickensided with remains of plants and streaks of coal, seen	1	
Total	18 ft.	1¼ in.

A similar section occurs on Buckhannon River about ten or eleven miles above the village of Buckhannon, but it is unnecessary to give it here. The coal is visible at many points along Roaring Creek to Tygart's River, and on that stream to within a few miles south from Grafton. On Roaring Creek, Mr. Jabez Woolley has measured it at three exposures, where he found the thickness eight, twelve and twenty feet respectively. Wherever it falls below twelve feet, it contains coal in sufficient bulk to be workable. The quality seems to be quite inferior throughout this region. Ex-Gov. Pierpoint informs me that some years ago it was proposed to mine this bed on Tygart's River, seven or eight miles above Grafton. The coal exhibited was very handsome, and to the naked eye showed no evidence of pyrites, but as soon as it was put under a glass it proved to be loaded with minute crystals of that mineral. It was thought

unnecessary to resort to chemical analysis for further information, and the enterprise was abandoned.

Near Weston, in Lewis county, this coal is said to occur in the bed of West Fork River, which is very probable, as the river cuts through the Laurel Hill anticlinal north from Weston. Following this anticlinal northward, we find it rapidly increasing in sharpness, so that at Valley Falls, where it is cut by Tygart's River, the Great Conglomerate is in the bed of the stream, and the Mahoning Sandstone barely crosses the crest unbroken. Near this point, at Nuzum's Mills, probably forty miles from Weston, the following section of the Lower Coal Group is obtained:*

	Ft.		*In.*
1. Sandstone	60		
2. *Coal*	3		
3. Sandstone	30		
4. Limestone	3		
5. Sandstone	30		
6. *Coal*, U. Freeport	5–6		
7. Sandstone	45		
8. *Coal*	2		
9. Fire-clay, compact	1		
10. Sandstone and shale	65		
11. *Coal*			6
12. Shale	15		
13. *Coal*	0–3		
14. Fire-clay, compact	3	to	6
15. Iron ore	2	to	6
16. Shale	15		
17. Great Conglomerate			
Total			

The *Upper Freeport* here shows, *Cannel*, 1 ft.; Bituminous *Coal*, 4 to 5 ft. It is somewhat inferior owing to the presence of much sulphur, but is a good strong fuel. On Prickett's Creek, in the same county (Marion), the cannel is at the bottom, and in greater quantity. Extensive arrangements were made here, years ago, for distilling oil from the coal, but the discovery of petroleum brought the enterprise to premature dissolution. On Booth's Creek, in Monongalia county, some old openings are still accessible. One a little way north from the creek shows:

Clay, 1 ft.; *Coal*, 1 ft. 11 in.; Clay, 8 in.; *Coal*, 2 ft. 9 in.; Clay, 2½ in.; *Coal*, 1 ft. 1 in.

A deserted opening near the old furnace on this stream gives:

Cannel, 1 ft.; Carbonaceous shale, 11 in.; *Coal*, slaty, 4 in.; Clay, 7 in.; *Coal*, 2 in.; Clay, 4 in.; *Coal*, seen, 4 ft.

* This section and the remaining notes on the Upper Freeport Coal were dropped by the printer in making up my previous paper on West Virginia.

The coal at the base is certainly much thicker than is stated. The old props lying in the deserted entry are somewhat more than five feet long. Another exposure near the mouth of the creek shows the bed much degraded, giving the following section:

Coal, 1 ft. 9 in.; Clay, 3 in.; *Coal*, 6 in.; Shale, 2 in.; *Coal*, 1 in.

The roof here is sandstone. Elsewhere upon the creek it is shale, which abounds in vegetable impressions. The coal from these openings is said to be very good fuel though it contains considerable proportion of sulphur. It contains much volatile combustible matter and cokes readily in heaps.

Returning to Upshur county, we find underlying the *Upper Freeport* Coal a sandstone about fifty feet thick, more or less flaggy, and apt to change into arenaceous shale. Below this is a thin tough limestone, not very pure, which seems to represent the Freeport Limestone. It was seen on the Staunton pike near Roaring Creek and on Sand Run. Between the limestone and the coal below, the sandstone is coarse and flaggy. The interval varies from twenty to thirty feet.

The next coal, No. 5, of the salt-well boring, was seen at only two localities, one on Roaring Creek, near the Staunton pike, and the other on Sand Run, near the great exposure of the *Upper Freeport*. It is a persistent bed and quite regular in thickness, varying little from four feet throughout this vicinity. The coal is irised, exceedingly rich in bituminous matter, and containing not a large amount of sulphur. It burns nicely and cokes well. No regular workings were found, and only "crop" coal could be examined. This is extremely brittle, so that, unless it improve greatly under the hill, it will hardly prove fit for shipping.

The beds, No. 7 and No. 9, of the boring have not been identified at any locality. Three miles east from Roaring Creek, and five hundred feet higher than the opening on the *Upper Freeport*, the blossom of a coal-bed occurs at the roadside. This is probably one of the lower beds, but the question cannot easily be determined, as eastward the dip increases rapidly in steepness, and the whole western slope of the mountain is so deeply buried under shingle and so thoroughly paved with fragments of sandstone and conglomerate, that connected exposures cannot be found.

East from this blossom, almost two-thirds of a mile distant along the pike, and very near the crest of the ridge, a coal-bed is worked. The mouth of the mine is three hundred feet higher that the blossom in the roadside. In the interval along the road everything is concealed except occasional exposures of sandstone. The bed near the crest is dipping northwestward at twelve degrees, so that the space between it and the coal above would be nearly five hundred feet, provided the dip does not vary. It is perhaps better to regard the interval as about four hundred feet. The coal is within a few feet of the conglomerate, but the inter-

vening rock is concealed. At the opening made by Mr. S. B. Hart, near the pike, the bed exhibits the following structure:

Shale, ——.; *Coal*, sulphurous, 4 in.; Black clay, 1 in.; *Coal*, 3 ft. 6 in.; Clay, 1 in.; *Coal*, 1 ft. 7 in.; total, 5 ft. 7 in.

The bottom coal is very inferior, being about one-half slate, and containing a notable proportion of pyrites. The bench next above it is a good fuel, though rather soft and toward the base somewhat sulphurous. It is extensively mined to supply Beverly and the adjacent country. I made as careful search for other outcrops as is possible in a wild region, covered with loose rocks and a dense forest. No other was found, unless the bed exposed at the head of Casseday's Fork of Buckhannon River be the same. This occurs near the crest of the ridge on the west slope, about ten miles south from the Staunton road. It is a large bed, and is most likely this coal. There is no doubt that this is the same with that found on the conglomerate in Marion and Monongahela counties. If it be as irregular in thickness here as in northern West Virginia and Ohio, its outcrop will be traced only with great difficulty.

Aside from the *Freeport*, itself reduced almost to nothing, no limestones were seen in this group. As in the other groups, the limestones disappear southward. They occur in Pennsylvania, but thin out rapidly after coming into West Virginia.

The Great Conglomerate.

This rock forms the crest of Rich Mountain for nearly sixteen miles, within the region examined. For the most part it is a coarse sandstone loaded with pebbles from ⅓ of an inch to 2 inches in diameter. Along the Staunton pike it shows some layers of slightly micaceous and very compact sandstone near the bottom. Here it is greatly increased in thickness. Near the northern line of the State it is barely three hundred and fifty feet thick, but in Randolph county, it is not less than six hundred. This expansion continues southwardly, as shown by the observations of Professor Fontaine, in the New River region. On Rich Mountain it contains no fossils, but in portions there are vast numbers of quartz crystals, some of them three-fourths of an inch long, and beautifully terminated at both extremities.

On the Staunton pike, along the eastern slope of the mountain, there was seen midway in the conglomerate, what appeared to be the blossom of a coal-bed. As I had observed no evidence of coal in the conglomerate northward from this locality, this exposure was studied with some care, but nothing definite could be ascertained. Six miles farther south, on the same side of the mountain, a small coal-bed occupies this place on the property of Mr. Bradley. There it is three feet thick, quite soft, but of excellent quality, and being almost free from sulphur, is highly prized by blacksmiths. Another opening has been made on the ridge near the bridle path, seven miles south from the Staunton pike, and a

third is seen near the same path, three miles farther south. These openings hardly deserve the name, as only a few sackfuls of coal have been taken from each. In all of them the coal shows the same character.

This little bed is of much interest. Here in the vicinity of the Staunton pike is the northern termination or better, perhaps, the beginning of the important group of "conglomerate" coals so fully described by Prof. Fontaine, in West Virginia, which farther southward become the main source of supply in Tennessee. In the northern portion of the State no coal occurs in the conglomerate. The local geologist, quoted by Prof. Fontaine and myself, who asserted that two beds occur in this group, is an ignorant man, who regarded the Tionesta Sandstone as part of the conglomerate, and so placed the Tionesta coals in this group.

Lower Carboniferous.

My observations in the Lower Carboniferous were made along the east slope of Rich Mountain at two or three localities between the Staunton pike and the Huttonsville bridle-path, a distance of somewhat more than ten miles north and south. The results therefore are not of much importance.

The red shales were seen on the Staunton pike. There they are in part quite arenaceous, and are almost a thinly laminated shaly sandstone. Their thickness cannot be accurately determined at that exposure, but I take it to be little more than fifty feet. They do not appear to contain any important deposit of iron ore, such as occurs near the Pennsylvania line. Six miles south from the Staunton pike, the shales are entirely wanting, and the conglomerate rests directly on the limestone. The line of contract is finely exposed at several localities but at none better than at a place nearly two-thirds of a mile north from Mr. Bradley's house, where the limestone and conglomerate are seen in contact along a bluff for about thirty feet.

The shales are of a deep red color, and the micaceous sandy layers are almost as deep red as the pressed brick on our house-fronts. As a whole, this series bears very close resemblance to the red shales of the Lower Barren Group, and might easily be mistaken for them. About fifteen miles north from the Staunton pike, at the gap made by Tygart's River on its passage through Rich Mountain, Mr. J. Woolley found these shales two hundred feet thick; their identity being certified by the conglomerate above and the limestone below. Within twenty miles south from that locality they have wholly disappeared.

The rapid thickening of the limestone is remarkable, contrasting strangely in this respect with those of the Coal Measures. Near the State line on Cheat River the limestone mass is barely one hundred feet thick, as ascertained by boring. In Randolph county, I saw a continuous exposure of nearly four hundred feet. A space of two hundred feet is concealed, and below that a calcareous shale occurs, so that the thickness is not less than seven hundred feet. In Pocahontas and Greenbrier

counties, the expansion is greater, reaching in the former to eight hundred feet. On the Staunton pike the topmost layers are exceedingly pure and very compact. They yield an excellent lime, and are the source of supply for the whole region to a distance of nearly twenty miles. Farther south the upper layers are quite impure, and are nearly calcareous shale. On the property of Mr. Bradley, a seam of *coal* occurs amid some shales in this mass, about two hundred and fifty feet below the conglomerate. It is two inches thick, quite impure and very sulphurous. It is seen in a little run below Mr. Bradley's house.

The fossils obtained from this limestone were found chiefly in the upper layers and are similar to those procured in Monongalia county. The most common are *Spirifer Leidyi*, *Athyris subquadrata*, *Productus elegans*, *Productus pileiformis*, *Hemipronites crassus*, *Allorisma sp.*, and *Straparollus planidorsatus*. These show the rock to be of the same age as the Chester group of the west. I had in my possession several fine specimens of *Lithostrotion canadense*, which were said to be from Randolph county, and I expected to find the St. Louis group well defined. No species belonging to that group fell under my observation, and I doubt whether the *Lithostrotion* came from this portion of West Virginia.

The strangest feature in the Lower Carboniferous of this region is the entire disappearance of the sandstones and shales usually found between the limestone and conglomerate. Judging from Rogers' reports, one would expect to find them, not merely persistent but greatly expanded, as compared with more northern localities. At Westernport, on the Potomac, they are six hundred and fifty feet thick, and in Pocahontas county, that adjoining Randolph on the *south*, they are twelve hundred and sixty feet. Yet in Randolph county they disappear completely. A local anticlinal must have existed here during the latter portion of the Lower Carboniferous period.

The Disturbed Region.

By this title I designate that portion of West Virginia lying between the line of the Ellenboro' fault and the Ohio River, which includes about midway between its east and west boundaries the especially broken tract known as the "oil-break."

The line of the Ellenboro' fault crosses the Staunton pike near Webb's Mills, on Hughes River. Northward it passes a little west from Harrisville and crosses the railroad about one-fourth of a mile east from Ellenboro'. Its place is entirely concealed on the Northwestern pike, though its presence there is indicated by the change in the character of the rocks. How far northward it extends I am unable to say, but if it continue in that direction, it should cross the Ohio River not far from New Martinsville. The best information within my reach leads me to suppose that it disappears long before reaching the Ohio. Southward this fault certainly disappears long before reaching the Great Kanawha River, for, according to Dr. Briggs, the *Pittsburg* coal shows a continuous outcrop

across the State through Braxton, Clay, Kanawha and Putnam counties to the Ohio River. Indeed, in every respect the disturbance from east to west in this region seems to have been greatest in the vicinity of the line followed by the railroad. Near Ellenboro' the fault is quite abrupt and is seen to good advantage in the creek's bed, about one-fourth of a mile from the station. On its eastern side the rocks of the Upper Barren Group are seen turned up and dipping at 26°, while on the west side the strata of the Lower Barren Group lie almost horizontally. The direction of the fault is about N. 10° E. Mag., and the upper rocks dip S. 80° E. Mag.

From this fault westward, the strata are almost horizontal, or have an easterly dip so slight that it cannot be determined by the barometer, until the edge of the oil-break is reached where they are abruptly turned up at a high angle. Within the "break," a narrow strip, nowhere more than two miles wide, the dip is irregular, but shows traces of anticlinal structure, and at no time exceeds 5°. On the west side the conditions seen at the east are repeated. The strata are sharply upturned and dip toward the west. The angle of dip quickly diminishes and soon becomes only ten feet per mile. About five miles east from Parkersburg, another fault occurs, quite as sharp as that at Ellenboro', with the upturned rocks dipping westward. Beyond this, the rocks are almost horizontal to the Ohio River.

On each side of the oil-break the strata belong to the Lower Barren Group, as far east the Ellenboro' fault and as far west as the fault near Parkersburg. What the rocks between this fault and the Ohio River are, can be determined only by approaching them from Ohio. Before entering into a discussion of the "break," it is well to describe these rocks as they occur east and west from it.

Lower Barren Group outside of the Oil-break. Near Ellenboro', and almost directly on the edge of the fault a boring was made several years ago in search of oil. No record has been preserved, but the enterprise proved unsuccessful. Both fresh and salt water were found, and a little oil was obtained. The rocks appeared to be much shattered. At first the drill descended nearly twenty feet each day, and farther down many crevices were struck, in which the tools would drop four or five feet instantly. Five hundred feet down, the drill stuck fast and the work was abandoned.

Along the railroad, westward from Ellenboro' to near Petroleum, the section appears to be :

1. Debris, with nodular limestone	75 ft.
2. *Coal*	1 ft.
3. Flaggy sandstone	40 ft.
4. Red shales	10 ft.
5. Sandstone	15–25 ft.
6. Red and blue shale	25 ft.
7. Sandstone	10 ft.
8. Red shales and sandstone	300 ft.

The limestone and coal both were seen near Ellenboro', as well as in the hills near a deep cut three miles farther west. This coal, I take to be the same with that whose blossom is seen in the roadside between Harrisville and Cornwallis Station, not far from the former place. The sandstones, Nos. 5 and 7, are soft, light gray, somewhat feldspathic and contain much mica. The upper is the more compact and durable. Both may be seen near Cornwallis Station, where the upper stratum is quarried extensively by the railroad company for building purposes. The lower one is apt to become flaggy. No. 8 is first seen near Cornwallis, and is the prevailing rock exposed in the cuttings from that place to near Petroleum, except near Silver Run Summit, four miles east from Petroleum, where the grade of the road brings one into the upper members of the group. The shales greatly predominate. When freshly exposed, they resemble a reddish shale enclosing nodules of sandstone. The whole, however, is a mass of slightly arenaceous clay shale, without definite bedding, of dull red color, with brownish patches, and readily breaking up into coarse powder on exposure. The color is characteristic, and once seen cannot fail to be remembered. No such shale occurs in the Upper Barren Group. It does occur in the Lower Barren Group along Buckhannon River and the Staunton pike, in Upshur county. No other group resembles it except the Red Shales of the Lower Carboniferous. Near Petroleum we find under it a sandstone, which, doubtless, belongs to the Lower Coal Group.

Along the Northwestern pike only the upper members of the group are exposed, until one approaches the eastern slope of this "break."

Southward from the railroad the rocks show the same character. At a short distance west from Harrisville a boring was made for oil. It was continued to the depth of five hundred feet and then abandoned. No record of it is accessible. I am informed that for most of the distance the drill passed through red shales, and that two very thin beds of coal or carbonaceous shale were passed through. On the Staunton pike, these rocks are well exposed for nearly twenty miles, by the road. They are said to contain two very thin beds of coal. Of one of these I saw the blossom about three miles west from Webb's Mills. It seems to be about ten inches thick. A very notable feature just east from the break is a sandstone, about twenty feet thick, resting on shale.

Leaving aside, for the present, all reference to the strata involved in the slopes of the oil-break, we pass across the break to the west, where we find a similar series of rocks, differing only in this, that the red tint is not the only one in the shale, many portions along the railroad having a bluish cast.

Upon the line of the railroad, west from Laurel Junction, we find the rate of dip quickly decreasing to less than one degree. Before reaching the tunnel, one mile west from the Junction, the blossom of a thin coal is seen in a low cut. This is probably two hundred feet higher than the rocks in the Junction cut, and is overlaid by a mass of bluish-red shale

and sandstone. From the tunnel westward to Walker's Station, the grade of the road falls, and meantime the dip becomes barely ten feet per mile. Nearly one mile east from Walker's, a thin coal is seen which may be traced through several cuts. It is eight inches thick, very slaty, and is no doubt the same with that just mentioned. Above it, in the hills is a succession of sandstones and red shales. Similar rocks occur all the way to Parkersburg. No break or fault was seen along the railroad, but in a well bored near Claysville, the strata are said to have been found much shattered. On the Northwestern pike the exposures are very incomplete ; no succession can be made out, but there are evidences of at least two small breaks in continuity of the rocks.

Upon the Staunton pike, the exposures are quite as satisfactory as those along the railroad, for the road runs in the valleys cut by the Little Kanawha and Hughes' Rivers. Starting up the Little Kanawha from Parkersburg, we find at five miles from that city a well-marked break or fault, very similar to that observed at Ellenboro'. Up to this point the westward dip is almost zero ; but here at once it increases to 25°. The exposure is at the roadside, in a cut. East from this break the strata are horizontal, at least no dip in any direction can be made out with the barometer. On both sides the rocks are apparently the same. Sandstones and brownish red, slightly arenaceous shales. Judging from their lithological characters alone, one would regard them as belonging to the same group. At a short distance below Newark, the road passes through a cut, in which is exposed a series of sandstones and dark-red shales, in all about one hundred and twenty-five feet thick. On top there is a handsome, light olive sandstone, which is quarried to supply material for building the locks on the river. Though soft, it is said to be quite durable.

At Greenville, where the road crosses Hughes' River, the same shaly sandstones and shales are seen in the river bluffs, and at some distance farther on, the massive sandstone appears in the hills, twenty feet thick and standing out as a cliff. Huge fragments of it have fallen off and lie strewn over the hillside, and in the river channel. It has been used here for building purposes, and serves well, as it is not very hard, dresses easily and is quite durable. This rock is seen along the road to within one mile of Freeport P. O., where the exposures become obscure, as we are approaching the western boundary of the oil-break. It is the same sandstone with that already mentioned as occurring just east from the break on this pike.

THE OIL-BREAK. This name is given to an irregular tract, from one to nearly two miles in width, having a general trend of N. 10° E. Mag., and with the strata on its sides, dipping N. 80° W. and S. 80° E. Mag. I have been able to examine it along the Staunton pike, the Northwestern Railroad, and the Northwestern pike, as well as at several points between these lines, embracing in all about fifteen miles of its length. The region of greatest disturbance is in the neighborhood of the railroad:

north and south from this line the abruptness diminishes. Its extent southward is not well determined. Col. Byrne, State Superintendent of Instruction in West Virginia, informed me that he had traced it to the Great Kanawha River, near Charleston. This seems hardly possible, for at the Great Kanawha, in that vicinity, there is no anticlinal, certainly there is no break. It is, however, by no means improbable that the remarkable horizontality of the strata there may result from the flattening out of this anticlinal in that direction, so that if the flattening occur gradually southward, the anticlinal might be traced to that river.

Northward, where the break crosses the Ohio River near Cow Run, it is said to be a gentle anticlinal, over which the upper rocks pass unbroken; and this belief is supported by Dr. Briggs' section along the Ohio.* In that section the whole mass between Wheeling and Pomeroy is referred to the Upper Coal Group, and the *Pittsburg* coal is regarded as being at no point more than two hundred and fifty feet under the river. There is certainly an error somewhere in this work, since in that portion of West Virginia, fronting on the river, a little south from Marietta, the surface rocks belong to the Lower and not the Upper Barren Group, for I have found the section along the Staunton pike to be the same on both sides of the break, and along the railroad it is practically the same. I have no records of borings made west from the break, but two on the east, one near Ellenboro' and the other near Harrisville, were driven five hundred feet and passed all the way through shales and sandstones, cutting at most only two streaks of coal. If these rocks belonged to the upper series, the *Pittsburg* coal should have been struck at about three hundred feet from the surface near Ellenboro', and at much less near Harrisville. At Wolfe's Summit, eight miles west from Clarksburg, the *Pittsburg* goes under, dipping northwestward, at the rate of somewhat more than one hundred feet per mile. From that place westward to Ellenboro', the strata of the Upper Coal and Upper Barren Groups are followed without a break, the dip continuing northwest all the way, though gradually diminishing in sharpness. At Ellenboro', the rocks change and the dip becomes slightly eastward. From this line we find only the characteristic red shales with the accompanying sandstones until we reach the oil-break where the rapidly-increasing dip brings us into the Lower Coal Group. As will be shown farther on, the rocks within and the steeply-sloping sides of the break form a continuous and uninterrupted series with those outside. If this series between the oil-break and the Ellenboro' fault belong to the Upper Barren Group, what has become of the Lower Barren and Upper Coal Group? Neither of these is found along the Staunton pike, where the whole structure is very clearly exposed. It is absolutely certain that the *Pittsburg* coal appears nowhere between the Ellenboro' fault and the one a little way east from Parkersburg, except possibly in isolated patches on tops of the very highest hills.

* Rogers' Report Geol. Virginia, for 1840.

Dr. Briggs' statement can be accounted for only by supposing that the Ellenboro' fault disappears long before reaching the Ohio, and that the oil-break itself flattens out rapidly, so as to become a low anticlinal near the river, over which the upper groups may pass unbroken. Still this does not wholly remove the difficulty. What the conditions may be above Marietta, along the river, I do not know, never having examined that region; but I do know that rocks belonging to the Lower Barren Group are found near Valley Mills, in Wood county, three miles from the river and seven miles northeast from Parkersburg. In that vicinity, I was unable to discover any rocks belonging to the upper groups.

The oil-break passes through Wirt, Ritchie and Pleasants counties. Beginning at the south, let us see the structure in the vicinity of the Staunton pike, which runs along Hughes' River. The section of the west slope is very prettily exposed on Fox's Run, about one mile north from the Staunton pike, where we find :

1. Red shales	not measured.
2. Shaly sandstone	20 ft.
3. Red shales	105 ft.
4. Shaly sandstone	30 ft.
5. Red shales	50–60 ft.
6. Sandstone, shaly to massive	65 ft.
7. Chert	5–12 ft.

No. 1 is not far from one hundred feet thick, and on it rests the massive sandstone already mentioned as seen along the pike west from the "break." Nos. 4, 5, 6 and 7 are wholly involved in the abrupt side, and No. 3, partially so. The sandstones are all of a dull red color, and in the wells bored just outside of the break, the whole mass was recorded as red shale. On the east side of the break the exposure is yet more satisfactory, as the road passes along the river bank, so low down as to exhibit the flexure in the flint where the dip abruptly decreases from 35° to 3°. The sandstones and shales of the preceding section are seen in the hill above the flint, thus proving indisputably that the rocks on each side of the "break" belong to the same horizon.

There is no evidence of faulting on either side. The succession from the inner portion of the abruptly tilted strata outward to the horizontal strata is unbroken and perfectly clear.

Within the break the rocks are almost horizontal and not much broken. They describe a flattened anticlinal, for beginning inside and proceeding outwards, say on the west side we find the dip first horizontal, then 2° or 3°, then 28°, then 56°, then 3° or 5°, and finally outside almost horizontal. A similar condition is found on the eastern edge. Along the line of section the chert is the last to show the abrupt dip.

If now we ascend the hill from Fox's Run and go east about one-third of a mile we find near Mr. Sharpnack's steam-mill, the sandstone and

chert almost horizontal. The sandstone is the highest rock in the hill. The section is as follows:

1.	Sandstone	60 ft.
2.	Chert	6–12 ft.
3.	Shale and limestone	9 ft.
4.	Black shale	3 ft.
5.	*Coal*	6–12 inches.
6.	Shale and sandstone	120 ft.
7.	Sandstone to river	not measured.

The chert is light-red to yellow, and in some cases dove colored. It is quite compact, and forms a striking feature in both sides of the break as well as on the hills within it. It is well exposed on the pike, where it has been used for macadamizing the road. The limestone in No. 3, occurs in nodules, varying from two inches to two feet in diameter. It is variegated and extremely compact. If a sufficient quantity could be obtained, this would be valuable as an ornamental marble for indoor use, since it receives a beautiful polish. The *coal* is sulphurous and slaty. It can be seen on the pike near each edge of the break. The sandstone, No. 1, is said to contain a *coal*, eight inches thick. The black shale overlying the *coal* No. 5, is quite rich in fossils. In a few minutes, I obtained from it a large number of individuals belonging to the following species: *Chonetes granulifera*, *Solenomya sp.*, *Schizodus sp.*, *Pleurotomaria grayvilliensis*, *Bellerophon montfortianus*, *Bellerophon percarinatus* and *Euomphalus subrugosus*. From this shale some very fine specimens of a *Nautilus*, allied to *N. occidentalis*, have been procured.

Near Freeport P. O., midway in the break, a well was bored to the depth of fifteen hundred feet, but the record seems to be wholly lost. All accounts agree in stating that for several hundred feet before the work was stopped, the drill passed through nothing but red shale. In a boring made near the middle of the break, thin coals are said to have been met at sixty, eighty and one hundred and twenty feet, respectively, from the surface. By comparing the results of two borings made here by Mr. J. Lillie, I make out the following partial section within the break:

1.	Sandstone	60 ft.
2.	Chert	6–12 ft.
3.	Shale and limestone	9 ft.
4.	Shale	3 ft.
5.	*Coal*	6–12 in.
6.	Shale	30 ft.
7.	Sandstone	59 ft.
8.	Shale	41 ft.
9.	Sandstone	105 ft.
10.	Shale	9 ft.
11.	Sandstone	76 ft.

12. Shale	14 ft.
13. *Coal*	3 ft,
14. Shale	20 ft.
15. Sandstone	27 ft.
16. Shale	6 ft.
17. Shale, black	10 ft.
18. Shale	50 ft.
19. Sandstone	20 ft.
Total	553 ft.

Oil was found in Nos. 9 and 19. The *coal*, No. 13, is said to be very soft and in appearance to resemble the Grahamite. It is not exposed everywhere and has been found only in borings.

Respecting the horizon of these rocks there is no room for doubt. The chert is undoubtedly the same as that found on the Great Kanawha River, immediately below the Mahoning Sandstone. Here, as so frequently elsewhere in West Virginia, that sandstone holds a thin bed of coal. The shale below the chert is rich in species of fossils, which, in the Appalachian region, are thus far utterly unknown at every horizon above the middle of the Lower Barren Group. Such a fossiliferous shale is very often found between the Mahoning Sandstone and the immediately underlying coal. From the sandstone down, the whole facies is that of the Lower Coal Group, and at an inconsiderable depth the shales of the Lower Carboniferous are reached.

Along the line of the Northwestern Railroad, the conditions are much more complicated, and one finds some difficulty in working out the true structure. Here the uplifting agency was exerted much more energetically than on any other line, whether north or south from the railroad.

Approaching Laurel Junction from the west, we pass through the Lower Barren Group. The strata are dipping westward very slightly until we approach the station, when the dip instantly changes to 30°, and within a very short distance increases to 75°. It then declines almost as rapidly to 2° or 3°. On the east side of the break near Petroleum, the conditions are similar, the easterly dip suddenly increasing from a fraction of one degree to twenty, and then to thirty-six degrees. On each side of the break the uplifted rocks are certainly not far from eight hundred feet thick, and they may possibly be somewhat more. The disturbed conditions renders it difficult to make a good estimate. In these rocks we find near Laurel Junction a thin coal bed, one foot, separated by about ten feet of shale from a slaty coal, barely eight inches thick. Both coals are badly broken, fire-clay and shale having been forced into them. From information given me by Prof. Fontaine, I am inclined to think that this same double bed is seen a little farther east in another cut, still sharply upturned. Near Petroleum, a similar bed is involved in the abruptly sloping rocks, and a little east from that village a thin coal is occasionally worked, which is said to be double and to resemble the one

under consideration. There seems to be no room for doubting that the coal near Laurel Junction and that at Petroleum are the same.

Prof. Fontaine, nearly two years ago, made a very careful section along the railroad from Laurel Junction to the middle of the break, where the summit of the anticlinal is shown. He has very kindly submitted his notes to me without restriction. In the main, the results of my observations do not differ from those previously obtained by him. I do not reproduce the section, as the details are unimportant here.

Within the break, that is, in that portion where the rocks lie somewhat irregularly horizontal, a *coal* is seen in several cuts. The section in connection with it varies slightly, owing to crushing, while the coal itself exhibits every evidence of having been subjected to strong pressure. The following sections were obtained at different points upon the railroad. No. I, being by Prof. Fontaine, and No. II, by myself:

I.		II.	
1. Massive sandstone	12′ +	1. Sandstone, massive	25′
2. Black arenaceous shale	5″–4′	2. Shale	2′–4′
3. *Coal*	30″	3. *Coal*	15″–23″
4. Gray sandstone	3½′	4. Sandstone and shale	6′
5. *Coal*	8″	5. *Cannel*	10″
6. Black shale	3′	6. Clay	3″
7. Flaggy sandstone	—	7. *Coal*	8″–12″
		8. Shale to track	6′

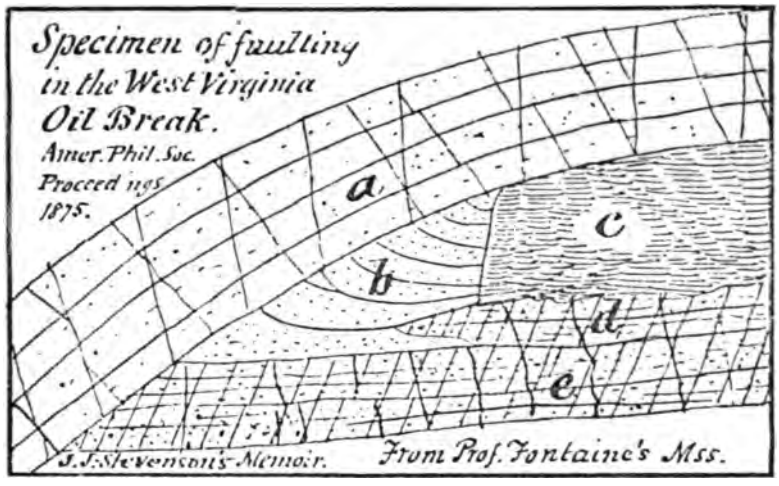
At the base of the massive sandstone there is a thin layer of conglomerate made up of rounded pebbles, one-half inch in diameter and cemented by oxide of iron. The shale contains no impression of plants. This seam is evidently the same as that mined near Volcano, about one mile north from the railroad, where the section to the coal, as obtained in a well, is shale 40′; sandstone, 40′–50′; *Coal*, 3′–5′. The *coal* is double and very irregular in thickness. Below it the rocks are principally sandstone to a depth of nearly five hundred feet, beyond which are reddish shales, which have been bored to seven hundred feet more without reaching their base. Two thin coals have been found within the break above this main bed, but they are not persistent.

Within the break the strata are thrown about in considerable confusion, and well-marked faults are not infrequent along the railroad line. One of these is exhibited in following figure, which, as well the description, I take from Prof. Fontaine's manuscript, the details being more satisfactorily given than in my own notes.

The fracturing of the rocks is especially marked on the western side of the break. The superintendent of one of the oil companies informed me that, on that side, it has never been found necessary to "torpedo" the wells, while that expedient is necessarily resorted to on the east side. The anticlinal structure is well shown west from Petroleum in the first cut which exposes the *coal*.

There is no room to doubt that the original structure here was that of an anticlinal, but certainly there is no true anticlinal now. This is easily shown by reference to only a few facts.

East and west from the break along the railroad, the rocks do not differ materially in character from those in similar position along the Staunton pike, where the relations are very clear. They are, therefore, of Lower Barren age. Borings made near the pike, say twelve miles south from the railroad, show the thickness of the Lower Coal Group and the Conglomerate to be not far from six hundred feet, and borings immediately north from the railroad show about the same thickne s. In the several cuts near Laurel Junction on the railroad, there are exposed several hundred feet of strata dipping at angles varying from ten to seventy-five degrees. These cannot belong wholly to the Lower Barren Group, for by far the greater portion has no equivalent in that group, being sandstone clearly underlying the mass of shales. From what we know of the Coal Measures in this portion of the trough, it is deemed impossible for the Barren Group to increase so enormously within barely twelve miles. The greater portion of these upturned rocks must belong to the Lower Coal Group, and must be identical with the shattered fragments arranged in rude horizontality between the sides of the break.



"'*a*'—rather heavy bedded gray sandstone, weathering reddish brown; '*b*'—thin sandstone plates, placed on each other like saucers, and abutting on '*c*,' which is a bluish fine shale; '*d*' and '*e*' are dark heavy bedded sandstones"

Such being the case, it is evident that we have here the remains of an anticlinal. All the conditions go to show that the upheaval was not slow, but very violent, even explosive. It seems as though the rocks had been blown out with such force as to fracture them on the crest of the anticlinal and as though the fragments, thus produced, had fallen into the broad gulf and keyed up the sides. In conversation, Prof. Fontaine has compared the conditions with those which would result if the top of a hollow anticlinal was battered in, and the simile is a good one. What the na-

ture of the agency producing the disturbance was, it is difficult to determine. It certainly was exerted over a broad area, extending in the region examined from the line of the Ellenboro' fault to the Ohio River. Fissures are frequent throughout this area, the most notable one being that containing the Grahamite. This has been fully described by Prof. Fontaine in the American Journal of Science.

The oil is obtained chiefly from rocks, which I regard as belonging to the Great Conglomerate. The grade, for which this region is particularly noted, is of heavy specific gravity and is known as lubricating oil. Lighter oils are obtained, but occur at a greater depth than the others.

Appendix. Since writing this paper I have received from Dr. W. H. Sharp, of Volcano, West Virginia, the records of eighteen borings made in different portions of the oil break. A comparison of these leaves no room for doubt that the strata within the break, though apparently horizontal, are badly broken up, in many places even dove-tailing or not infrequently crushed into irregular masses. This is sufficiently evident from the variations in the interval between two well marked strata,—the coal-bed, already mentioned, and a limestone at some distance below. It is possible, however, to make an approximate estimate of the thickness of the rocks, for several wells bored at somewhat distant localities show a close agreement. I give condensed sections of four borings. No. I is near the eastern edge; No. II is in similar position, but one mile farther south; Nos. III and IV are near the central line of the "break" and were made on lots 56 and 33 of the Volcanic Company's tract:

I.

1. *Coal*	3′	
2. Shale	7′	387 feet.
3. Sandstone	23′	
4. Dark Shale	63′	
5. Gray Sandstone	79′	
6. Light Shale	33′	
7. Gray Sandstone	24′	
8. Shale and S. S.	81′	
9. Aren. Shale and L. S.	77′	
10. *Limestone*	22′	
11. Shale	101′	133 ft.
12. Sandstone	32′	
13. Variegated Shale	388′+	

II.

1. *Coal*	3′	
2. Interval not given in detail, but chiefly Gray Sandstone	233′	
3. *Limestone*	25′	
4. Shale and Sandstone	123′	135 ft.
5. Sandstone	12′	
6. Variegated Shale	213′+	

III.

1. *Coal* and Shale	8′	
2. Sandstone	80′	426 feet.
3. Dark Shale	32′	
4. Gray Sandstone	16′	
5. Shale	128′	
6. Sandstone	170′	
7. *Limestone*	8′	
8. Sandstone and some Shale	128′+	

IV.

1. *Coal* and Shale	11′	
2. Sandstone	17	338 feet.
3. Dark Shale	12	
4. Sandstone	58	
5. Shale	48	
6. Shale and S. S.	23	
7. Sandstone	82	
8. Sandstone and S.	56	
9. Sandstone	42	
10. *Limestone*	17	
11. Sandstone &c.	39 +	

In these sections the interval varies from 233 to 426 feet. In another boring, which passes through both the coal and the limestone, the distance is 364 feet. Two other wells were driven to a depth of 386 and 397 feet respectively below the coal, without reaching the limestone. In all these wells the succession of strata is strikingly similar, though there is no resemblance in the thickness of individual layers. It seems quite probable that the interval is not far from three hundred feet, making all due allowance for exaggerated thickness owing to irregular dip of the rocks. The abrupt variations in the interval can be accounted for only by supposing that the strata are not only broken, as they usually appear in many of the railroad cuttings, but also actually crushed by lateral pressure, as indeed is shown in one of the illustrations given above. That this crushing is a common phenomenon appears from the frequent occurrence of the term "floating sand" in the records.

The record of one boring gives, as overlying the limestone, "18 feet of sandstone and *coal*." Since this coal is referred to in no other record, I am inclined to regard the statement as an error. Above the main coal and separated from it by a thin stratum of shale, there is in every instance a sandstone, whose thickness appears to vary from 20 to 80 feet. On this in two localities and eighty-five feet above the main bed is a thin coal, two feet thick, and, at one place, still another seam, of similar thickness occurs sixty-three feet higher. Above are shales for a considerable distance, probably two hundred feet. These borings confirm the conclusion, previously given, that the main coal is the Upper Freeport of Pennsylvania, the No. VI of Ohio.

Eleven of the borings pass through the limestone and five others show by their sections that they have stopped not far short of it. In fourteen of these, the overlying rock is described as sandstone and in the other two as sandy shale. In twelve instances the sandstone is more or less conglomerate. Respecting the limestone I have no direct information. It is seen in a run near the railroad, a short distance east from Laurel Junction, but no search has been made in it for fossils. Under the limestone, sandstone occurs in ten borings and black shale in one. In four instances the sandstone is quite conglomerate. Below the sandstone is the variegated shale, whose thickness is unknown. Near the Staunton pike it is more than seven hundred feet.

This succession leaves no room to doubt that the overlying rock is the Great Conglomerate, that the limestone is the Lower Carboniferous limestone (Umbral) and that the underlying rocks are the Waverly Conglomerate and shales (Vespertine).

Oil is found in the Great Conglomerate as well as in the shales and conglomerate of the Waverly. The heavy lubricating oil, for which this district has been celebrated, occurs at the upper horizon, while the lighter oils are obtained at greater depths. Dr. Sharp informs me that extensive "water-veins" are seldom encountered in the borings.

ON THE TRAPS OF THE MESOZOIC SANDSTONE IN YORK AND ADAMS COUNTIES, PENNSYLVANIA.

By Persifor Frazer, Jr., A. M.

(*Read before the American Philosophical Society, April* 16, 1875.)

Chemical Properties.

All igneous rocks consist principally of compounds of some kind of feldspar (or Nepheline or Leucite) with pyroxene, hornblende, mica or quartz, and generally with some magnetite and other subordinate minerals. All these again may be divided into those poor in Silica or Basic, or those rich in Silica or Acidic.*

The average compositions of these two kinds of igneous rocks are:

	BASIC.		ACIDIC.	
	PER CENT.	AVERAGE.	PER CENT.	AVERAGE.
Silica.....	45–60	52	55–80	67
Alumina.. ..	10–25	17	10–15	12
Ferrous oxide / Ferric oxide	1–25	13	1–15	8
Lime.....	1–15	8	0–8	4
Magnesia....	1–12	7	0–4	2
Potash.....	1–9	5	1–11	6
Soda.....	1–7	4	2–8	5
Water.....	0–4	2	0–6	3

Taking these ideal average percentages of the constituent compounds of these two classes of rocks, throwing them into a more convenient form and neglecting small fractions, we have:

BASIC.

	PER CENT.	OXYGEN.	OXYGEN RATIO.
Silicon.....	24.96	27.0	27
Aluminum.....	9.00	8.0	10
Iron from Fe_2O_3 say.....	4.5	2.0	
Iron from FeO say.....	5.0	1.5	10
Calcium.....	5.7	2.3	
Magnesium.....	4.3	2.7	
Potassium.....	4.1	0.8	
Sodium.....	2.9	1.0	
Hydrogen.....	0.2	1.8	
Total oxygen.....		47.1	

Of course it is understood that these figures represent no combination

* Rocks Classified and Described, by B. v. Cotta. Translated by H. Lawrence. London. Longmans, Green & Co., 1866.

of elements actually possible, and that the ratio of the Oxygen of the Silica to that of the protoxide and sesquioxide bases is only approximative to that of a mixture of minerals representing a mean of the highest and lowest percentages of those elements which are more commonly found in Basic igneous rocks.

The same remark applies equally to the next following class :

ACIDIC.

	PER CENT.	OXYGEN.	OXYGEN RATIO.
Silicon	32.16	34.84	34.84
Aluminum	6.38	5.62	6.82
Iron from Fe_2O_3 say	2.80	1.20	
Iron from FeO say	3.08	0.92	9.67
Calcium	2.86	1.14	
Magnesium	1.22	0.88	
Potassium	3.24	2.76	
Sodium	3.70	1.30	
Hydrogen	0.33	2.67	
Oxygen		51.33	

Bunsen's* classes were as follows :

	PYROXENIC.	TRACHYTIC.
Silica	48.47	76.67
Alumina / Ferric oxide	30.16	14.23
Lime	11.87	1.44
Magnesia	6.89	0.28
Soda	1.96	3.20
Potash	0.65	4.18
Total	100.00	100.00

Bringing them into the same form as the above, we have :

PYROXENIC.

	PER CENT.	OXYGEN.	OXYGEN RATIO.
Silicon	23.26	25.21	25.21
Aluminum (say 15 p. c. Al_2O_3).	7.95	7.05	11.60
Iron (say 15.16 p. c. Fe_2O_3)	10.61	4.55	
Calcium	8.47	3.40	6.69
Magnesium	4.22	2.67	
Sodium	1.45	0.51	
Potassium	0.54	0.11	
Oxygen		43.50	
Total acid and basic radicals	56.48		

* Pogg. Ann., 1851, Vol. LXXXIII.

TRACHYTIC.

	PER CENT.	OXYGEN.	OXYGEN RATIO.
Silicon	36.80	39.87	39 87
Aluminum (say 7 p. c. Al_2O_3)	3.71	3.28	5.45
Iron (say 7.23 Fe_2O_3)	5.06	2.17	
Calcium	1.03	0.41	2.06
Magnesium	0.17	0.11	
Sodium	2.37	0.83	
Potassium	3.47	0.71	
Oxygen		47.38	
Total acid and basic radicals	52.61		

In the Journal of Science and Arts, Vol. IX, March, 1875, is a paper by Mr. Geo. W. Hawes, on the Trap Rocks of the Connecticut Valley, in which a number of closely accordant analyses of dolerites are given, the specimens being selected from various localities in the Mesozoic Sandstone Belt of that State.

A Dolerite taken from a dyke known as West Rock, and standing west of New Haven, gave to Mr. Hawes the following results, which have been embodied in the form of the preceding hypothetical compositions.

ANALYSIS I, OF WEST ROCK.

	PER CENT.	OXYGEN.	OXYGEN RATIO.
Silicon	24.86	26.94	27.02
Phosphorus	0.06	0.08	
Aluminum	7.55	6.65	7.72
Iron (from Fe_2O_3)	2.48	1.07	
Iron (from FeO)	6.36	1.90	8.58
Manganese (from MnO)	0.32	0.10	
Calcium	7.58	3.00	
Magnesium	4.67	2.96	
Sodium	1.59	0.56	
Potassium	0.32	0.06	
Ignition	0.63		
Oxygen		43.32	
Acid and basic radicals	56.42		

On comparing this analysis with the hypothetical composition of Cotta's Basic Igneous Rock, it will be observed that the Silicon (including under this head the small per cent. of P. present in West Rock), is almost the same in both, as also is the percentage of radicals in the pro toxide bases, while the per cent. of Oxygen of both protoxide and ses-

quioxides, and the per cent. of the radicals of the sesquioxide bases are somewhat less in the actual, than in the hypothetical analysis.

In tabular form the proportions would stand as follows :

	HYPOTHETICAL BASIC IGNEOUS ROCK.	WEST ROCK.
Silicon	24.96	24.92
Oxygen	27.00	27.02
Aluminum, Iron (from peroxide)	13.50	10.03
Oxygen	10.00	7.72
Radicals of protoxide bases	22.20	20.84
Oxygen	10.00	8.58

A mean of 40 analyses of Labradorite recorded in Dana's Mineralogy, is as follows :

	PER CENT.
Silica	53.09
Alumina	27.96
Ferric oxide	1.33
Magnesia	0.93
Lime	10.88
Soda	4.09
Potash	1.08
Water	0.84
Total	99.39

Or in the simple form :

	PER CENT.	OXYGEN.	OXYGEN RATIO.
Silicon	25.48	27.61	27.61
Aluminum	14.73	12.96	13.36
Iron (from Fe_2O_3)	0.93	0.40	
Magnesium	0.24	0.15	5.26
Calcium	7.77	3.11	
Sodium	3.03	1.06	
Potassium	0.98	0.19	
Hydrogen	0.09	0.75	

Mr. Hawes extracted enough crystals of pyroxene from one specimen of Connecticut trap to enable him to determine its constitution.

It bears the nearest resemblance to an Augite of the Rhone, analyzed by Klaproth :

	Si.	Al.	Fe.	Mn.	Ca.	Mg.	Ignition, Alkalies and Loss.	Total.
Connecticut pyroxene .	24.34	1.88	11.90	0.63	9.53	8.34	2.65	56.62
Oxygen.....	26.37	1.76	3.40	0.18	3.82	5.29		40.82
Augite (Rhone*).....	24.96	3.06	8.48	0.19	1.00	7.80	4.23	54.49
Oxygen.....	27.04	2.70	2.54	0.06	4.00	4.95		41.29

Assuming the pyroxene analyzed by Mr. Hawes to represent that constituting part of these traps, and assuming furthermore, the above average of 40 analysis of Labradorite as constituting the remaining part, we have the following comparative table, which is calculated by comparing the sum of the percentages of each element of the two minerals with double the percentage of the same element in West Rock.

PER CENT.

Elements.	Labradorite.	Augite.	West Rock.		
			Double Equivalent.	Deficient.	In Excess.
Si.	25.48	24.34	49.72	0.10	—
P.	—	—	0.12		0.12
Al_2^{vi}	14.78	1.88	15.10	1.51	—
Fe_2^{vi}	0.93	—	4.96	—	4.03
Fe'' & Mn''	—	12.53	13.36	—	0.83
Ca.	7.77	9.53	15.16	2.14	—
Mg.	0.24	8.34	9.34	—	0.76
Na.	3.03	1.65(?)	3.18	1.50(?)	—
K.	0.98	1.00(?)	0.64	1.34(?)	—

Of the constituents necessary to form a mixture of one molecule of each of the above mentioned minerals, there are in West Rock :

* Dana's Min., p. 218, II. 7.

CHEMICAL UNITS.

Elements.	Deficient.	In Excess.
Al_2^{vi}	0.165	—
Fe_2^{vi}	—	0.216
Fe'' & Mn''	—	0.030
Ca.	0.107	—
Mg.	—	0.063
Na.	0.065	—
K.	0.034	—
Sum.	0.371	0.309
Si.	0.014	—
P.	—	0.011

Supposing the basic radicals in excess to replace those deficient, there are wanting 0.062 (= 0.28 p. c.), and of the acid radicals 0.003 units (= 0.018 p c.) to fulfil theoretical requirements.

Or, to throw this into a rough practical form susceptible of easy comparison:

Double Equivalent of Constituents of West Rock.

Si (P. &c.)	24.92 × 2		25.48	1 molecule Labradorite.
			24.34	1 " Augite.
	=	49.82	49.82	
Al_2^{vi} &c.	10.03 × 2		15.66	1 molecule Labradorite.
			1.88	1 " Augite.
	=	20.06	17.54	
Dyad and Monad Basic Radicals,	20.84 × 2		11.80	1 molecule Labradorite.
			30.40	1 " Augite.
	=	41.68	42.20	

A specimen of Dolerite was taken from Beeler's farm, 2 miles S. W. of York, York county, Pa., and submitted to Dr. F. A. Genth for analysis, which is as follows :

	PER CENT.				Oxygen.
Silicic acid	52.53	Silicon	24.51		28.02
Phosphoric acid	0.15	Phosphorus	0.06	28.24	0.10
Titanic acid	0.32	Titanium	0.19	—	0.12
Alumina	14.35	Aluminum	7.65	8.48	6.70
Ferric oxide	5.93	Iron (from Fe_2O_3)	4.15		1.78
Ferrous oxide	5.45	Iron (from FeO)	4.23	—	1.21
Manganous oxide	trace	Manganese	—	—	—
Magnesia	7.99	Magnesium	4.79	—	3.20
Lime	10.27	Calcium	7.33	8.00	2.94
Lithia	faintest trace.	Lithium	—		—
Soda	1.87	Sodium	1.38		0.49
Potash	0.92	Potassium	0.76	—	0.16
Copper	trace.	Copper	—	—	—
Sulphur	0.08	Sulphur	0.08	—	—
Ignition	1.23				
Total	101.04				

These constituents in chemical units give:

Silicon	3.500	3.515
Titanium	0.015	
P —	—	
Aluminum	0.834	2.050
Iron (from sesquioxide)	0.222	
Iron (from protoxide)	0.150	
Magnesium	0.399	
Calcium	0.366	
Sodium	0.060	
Potassium	0.019	
Difference		1.465

DOLERITE FROM BEELER'S.

Total units in rock	11.130
Chemical units of Si. and Ti	3.515
" " of basic radicals	2.050
Excess of units of Silicon, &c.	1.465

(*Neglecting Sulphur*)

	CHEM. UNITS.
Total chemical units of oxygen	5.565
Excess of units of acid over basic radicals (= units of saturating oxygen)	1.465
Linking oxygen	4.100
= 32.80 p. c.	
Saturating Oxygen = 11.72 p. c.	

Hence the conclusion that 4.09 p. c. of this rock is Silicon combined as ortho-silicic acid, according to the formula $M'_4Si^{iv}O''_4$, and the remaining 20.51 per cent. exists in the form of the mono-meta acid, or as $M'_2Si^{iv}O''_3$.

The excess of the chemical units of Si. over those of the basic radicals, will also serve to explain the fact (mentioned to me by Mr. Hawes in reference to the Ct. Traps, but which I have not yet sufficiently verified in those from our own State), that in many cases free Silica is observed in them.

It may be added that the reduction of the analysis of these rocks to a form which gives the measure of chemical force employed in the composition of their constituent minerals, and in a single unit, *i. e.*, the ratio of the percentage weight by the equivalence to the atomic weight, seems a very convenient one to employ in discussing the questions here considered.

It is interesting to observe that while the analysis of the Connecticut Dolerite agrees very well with a mixture of one molecule of Labradorite to one of Pyroxene, that from Beeler's farm corresponds even more closely with a mixture of two molecules of Labradorite to one of Pyroxene. In this table the same analyses of Labradorite and Pyroxene are used as in the former case.

	3 molecules of Beeler's dolerite.			
			49.40 (24.7 × 2)	2 molecules of Labradorite.
Si.	24.65 × 3		24.34	1 molecule, Pyroxene.
	=	73.95	73.74	
Al_2^{vi} &c.	11.81 × 3		32.40 (16.2 × 2)	2 molecules, Labradorite.
			1.88	1 molecule, Pyroxene.
	=	35.43	34.28	
			23.60 (11.8 × 2)	2 molecules, Labradorite.
Dyad and Monad Basic Radicals,	18.45 × 3		30.40	1 molecule, Pyroxene.
	=	55.35	54.00	

OPTICAL PROPERTIES.

Syenite (?) from Cemetery Hill, near Gettysburg, Adams Co., Pa.

Contains Feldspar, Hornblende and Magnetite, and some Biotite, with Quartz rarely. With a single Nicol's prism, the blades of Hornblende are fully dichroic. Both that and the feldspar are speckled and spotted.

Between two Nicol's prisms the Labradorite polarizes through blue, yellow, and lilac; the Hornblende from white to brown and black; and the Quartz, which is sparingly present, gives brilliant colors.

In the thick specimen examined under the microscope the feldspar differs from that of the equally thick specimens of dolerite in being more transparent and "icy"-looking, resembling Adularia, and here and there are seen small grains of a transparent mineral giving the rainbow colors of quartz.

The fine slice reveals the feldspar in a state not easily distinguishable and of weathered appearance, and also several objects, which from their colors, green and red, resemble small fragments of pyroxene. While therefore, there is no doubt of the occurrence of hornblende in sufficient quantity to give the character to this rock, the question as to its proper name will be remanded to future study.

Dolerite from Beeler's Farm, 2 Miles S. W. of York.

This slide at 275 diameters and between Nicol's prisms, shows an aggregate of irregular portions of crystals of pyroxene and Labradorite with the accompanying magnetite. The surfaces of the crystals are rough, but they do not seem to be so much affected by weathering as in that marked No. 3.

Dolerite (No. 3) from Beeler's Farm, 2 Miles S. W. of York.

The Labradorite and pyroxene of this specimen, under 275 diameters, appear in much the same condition as those of the slide from the Mumper dolerite. The blades of Labradorite are twinned and sometimes geniculated; the two individuals polarizing alternately light and brown.

Certain parts of this slide are very rich in a fine rod-like crystal apparently uniaxial which may be set down with safety as apatite. A very large number of these little crystals is distributed throughout the whole mass.

Dolerite from Mumper Shaft, 1 Mile N. of Dillsburg, York Co., Pa.

The thin section (magnified 56.8 diameters) and with $\frac{1}{8}$ in. aperture, exhibits blades of Labradorite very finely and regularly striated, mixed together with yellowish green masses of pyroxene irregularly cleft and stippled on the surface like fish roe and containing magnetite, around which is to be seen a brownish-yellow stain due to its partial conversion into ferric hydrate. With appertures of $\frac{1}{2}$ in., $\frac{1}{4}$ in., and 3-16, the same appearances are manifest, but not so clearly.

With the Lieberkühn reflector the fragments of magnetite assume a partially metallic lustre.

With one Nicol's prism there is a faint appearance of dichroism in some isolated spots of some of the pyroxene crystals but in general there is no change.

Between two Nicol's prisms the pyroxene changes from green to pink (sometimes giving a transient spot of deep purple), and the irregular rifts in its mass are more plainly visible.

The Labradorite changes abruptly along the planes of twinning to light brown and pale greenish-blue from white. The striation is very apparent and polarization is usually complementary in two or three sections of the single blade.

The magnetite of course remains unchanged.

Between Nicol's prisms and magnified 275 diameters the outlines of the constituent crystals of this rock are very sharp, and the pyroxene in particular shows very brilliant shades of purple and green.

The cleavage is quite apparent, and the whole rock seems but little altered.

Dolerite from Logan's Shaft, 1 Mile N. of Dillsburg.

This slide resembles the others but is less decomposed and compounded of finer crystals than the others. It exhibits Labradorite, pyroxene and magnetite, besides acicular crystals which appear to be apatite.

Under 275 diameters the Labradorite and pyroxene have a rough appearance, as if covered with little bubbles, due perhaps, to incipient decomposition. A number of small needle-like apatite crystals are scattered through the mass.

The greater part of the Labradorite (which is twinned as usual) lacks sharpness of outline.

The photographs and zinc plates from the photo-zincograph process have been prepared by Mr. Anthony Wenderoth, of this city, to whom great credit is due for his skill in overcoming what have been hitherto considered insuperable difficulties. In the present state of photography it is impossible to make a picture from nature of the constituents of a complex rock of this kind, and at the same time to preserve the identity of each to the eye. Indeed the outlines of the separate minerals will blend more or less into each other when the colors are such as will affect the sensitized plate imperfectly. Another drawback is that yellow and red minerals photograph black, and the former being one element of the color of many pyroxenes, the black spots, which should indicate magnetite, are sometimes extended out of all reason, when the two last mentioned minerals occur together. Another evil is that the same mineral may, by reason of slightly differing thicknesses in different parts of the slide, assume totally different colors. And still another, is that part of the stippled effect is often due to the necessities of the process. Yet in spite of these disadvantages, some of which at least experience and patience will enable

us to overcome, these plates are among the most faithful representations of the facts as seen through the microscope which have yet appeared.

With suitable apparatus and after some prefatory trials, I have hopes of producing more perfect results, and of obtaining sharp level photographic outlines, which can be colored if necessary to correspond to five or six positions of the analyzer during its rotation.

[NOTE —In connection with this paper a series of thin slices of Connecticut Traps, made by Mr. E. S. Dana, of Yale College, the Pennsylvania specimens referred to in the text, as also, photographs of maps of York County and Gettysburg, and the positive picture on glass of the slices of 136 diameter enlargement, were projected on the screen.]

EXPLANATION OF THE PLATES.

PLATE I.

FIG. 1. This photograph was among the first made with an $\frac{8}{10}$ microscopic objective. A portion of the edge of the section was included in the field in order that the portion represented might be more easily recognized and studied under the table-microscope.

The enlargement is very nearly 34 diameters. The original is a dolerite (No. 3) containing pyroxene (*a*), magnetite (*b*), plagioclase (labradorite) (*c*), and some scattered needles of apatite (*d*).

The previous description of the dolerite No. 3 from Beeler's farm applies to this specimen.

FIG. 2. The negative of this print was made in polarized light and is another portion of Fig. 1, Pl. IV.

The object is a specimen of dolerite from Beeler's farm marked No. 4.

The rock is seen to be a confused mass of crystal fragments consisting of labradorite (*a*), pyroxene (*b*), and magnetite (*c*).

PLATE II.

FIG. 1. The negative of this print was taken with a $\frac{1}{5}$ microscopic objective, and the enlargement is about 136 diameters. The minerals constituting this rock, (which occurs on Cemetery Hill, Gettysburg, Adams County, Pa., and has been provisionally called Syenite,) are more or less weathered, as their rough appearance, caused by their numerous cavities, sufficiently shows.

a. Crystals of feldspar.

b. Hornblende.

c. Magnetite.

FIG. 2. This object is specimen 1 of dolerite from Beeler's farm, 2 miles S. W. of York, and is magnified 136 diameters.

a. Labradorite.

b. Pyroxene.

c. Magnetite.

The surfaces of both feldspar and pyroxene (and especially of the latter) are covered with small cavities.

PLATE III.

FIG. 1. This is a dolerite from Logan's, a shaft contiguous to the Mumper shaft. Besides exhibiting the relations of the light-colored slabs of labradorite to each other, and the pyroxene which forms a matrix for them, there are two distinct apatite crystals reproduced in the print.

a. Labradorite.

b. Pyroxene.

c. Apatite.

Central black spot, Magnetite.

FIG. 2. Thin section of a dolerite from a shaft on Mumper's property about 1 mile N. of Dillsburg. The dyke of which this is a section cuts the ore bed at a short distance beneath the surface.

In this print there is a labradorite of unusual size, in which is imbedded a small mass (of pyroxene) (?) which appears black in this light. The striation of other labradorite crystals is distinctly seen, while the outlines of the magnetite crystals are unusually sharp.

a. Labradorite.

b. Pyroxene.

c. Magnetite.

PLATE IV.

The figures in this plate were photographs of the same object but under different conditions of polarized light. Figs. 1 to 5 inclusive, were photographed in five different positions of the analyzer. A peculiar crystal of pyroxene which exhibits a median line differing in color from the body of the crystal was made the guide. The purpose of these experiments was to see whether means could not be discovered to di criminate between the effects of anactinic light and opacity, by the camera alone. The object was a thin section of a dolerite from Beeler's farm, 2 miles S. W. of York, marked No. 4.

FIG. 1. This pyroxene appears of a light color and with a dark core, which in turn contains an irregularly formed light-colored axis. The boundary between this crystal and the magnetite at its right hand extremity is sharply defined; and the division between this pyroxene and a neighboring fragment just below its lower edge is also evident.

FIG. 2. In this photograph polarizer and analyzer are in the same phase. The main crystal is still light-colored, but there is less definition about the middle part of its dark nucleus, a light band extending nearly across it at this place. The pyroxene lying below its lower edge, which was dark in Fig. 1, has now become light, and the line of division between the two crystals is nearly obliterated, except at one point where a small magnetite appears in relief against the light background. The angle of the analyzer was not determined.

In Fig. 3, the main crystal has become almost entirely black with a light core. The upper end now blends with the magnetite alongside of it, and the pyroxene on the lower side has become sensibly darker, but still leaves the small crystal of magnetite apparent. The angle of the analyzer was not determined.

In Fig. 4, with an angle of $\pm$ 135° from the first position, the appearance is nearly the same as in Fig. 1; and in Fig. 5 as in Fig. 3.

In Fig. 6, which was taken in the same position of the analyzer as Fig. 4, a new condition was introduced, viz.: a thin plate of selenite was interposed over the slide and between polarizer and analyzer. The effect is a general resemblance to Figs. 1, 2 and 4.

These attempts to utilize the art of micro-photography, for the delineation of the facts as seen through a microscope of moderate power, are yet crude and undoubtedly susceptible of very great improvement, and my only excuse for offering them to the Society in their present unfinished state, is the supreme importance of using every means in our power at the present time to illustrate the conditions of structure of these micro-crystalline (once crypto-crystalline, but now so no longer) igneous rocks; and the hope that the effort to enlist the pencil of the sun in these reproductions, however imperfect it may be in its beginning, may be ultimately successful.

It has not been attempted in this paper to specify *all* the constituents of these traps; to do this a further laborious study of many more slides would be necessary: but only to point out those of most frequent occurrence and of principal importance, which can be recognized in the photographic representations.

ON CREMATION AMONG THE DIGGER INDIANS.

By W. J. Hoffman, M. D.

(*Read before the American Philosophical Society, April* 16, 1875.)

In my last communication, I described, in part, the funeral ceremony of that sub-tribe of Pah-Utes inhabiting the vicinity of Spring Mountain, Nevada, and in looking over my notes made in 1871–2, I find that cremation was also practiced by the Digger Indians (Pah-Utes) living around Marysville, Cal. I would here state, that as far as I have been able to compare the language, or rather dialects, customs, beliefs, ethnology, etc., I am inclined to trace the various sub-tribes of Utes, Pah-Utes (including Diggers) and Gosh-Utes, to one common type. Their bands are scattered over an extent of country, from the northern interior portion of California, southward throughout that State to Owen's Lake, thence irregularly eastward into Utah and Colorado, making a distance between the two limits of about one thousand miles. The dialects are similar to a great extent, except where they have adopted many Spanish words, and these incorrectly pronounced.

Cremation as practised at Marysville, is very similar to the form at Spring Mountain, but to give as clear an idea as possible, I shall repeat it. When an Indian (*e. g.*, a male) becomes dangerously ill, all the remaining ones of that *rancheria* move a short distance away, leaving the sufferer to himself. The wife, or one of his relatives, supplies him daily with food and water. In case death ensues, the male friends of the defunct prepare everything for the usual ceremonies. Some, wrap the corpse into a blanket, and tie it with grass ropes to keep the body stiff and straight; while others gather pine wood, which they arrange into a pile about four feet broad and eight feet long, high enough to contain rather more than a cord, upon which the corpse is placed, with all his favorite valuables, such as bows and arrows, blankets, gun, etc. All the Indians then form a circle around the pile, fire is applied, and several men are stationed near, with long poles, to stir up the coals and burning embers, to hasten the work. When the body has been reduced to the smallest possible quantity or bulk, (ashes or crisp) the widow approaches and scraping up some of the resinous exudation of the pine, covers her face and hair with it, signifying that she will not entertain any proposals of marriage as long as any trace of the resin adheres to her person. The remains are then collected and transferred to a piece of blanket or buckskin, in which they are buried near camp. Their reason for burning all the usual trinkets, etc., of the dead, is the same as at Spring Mountain, *i. e.*, that when the Indian reached the better land (the white man's hunting-ground in the direction of the rising sun), he must be prepared to take part in the chase, as he was wont to do on this earth.

* * * * * * *

The Modocs, now so well known, also practised this custom as late as the year 1868, when it was discontinued, they having adopted the mode of burial practised by the tribes living to the north of their territory. The only differences were that the chief mourner would cover his (or her) face and hair with the blood and grease which ran from the burning body, instead of using the resin; and that the ashes were buried, usually, in a small basket made of grass or fine roots, and shaped like a small basin or bowl. The ashes were also buried near camp, from two to three feet below the surface.

In conclusion, I would say, if the name *Digger* is applied to those Pah-Utes who obtain their food to a great measure from the ground such as roots, lizards, etc., etc., why not call those tribes Diggers also who are lower in the scale of humanity, as the Seviches, who live on the Colorado Plateau, near the western terminus of the Grand Cañon. They are decidedly the most loathsome beings who live within the limits of the United States. (I shall report more accurately upon this, and adjoining bands in some future paper.) The Sho-sho-nees and their sub-tribe, the Snakes, also live on roots, herbs, lizards, toads and insects, besides the fish and fowl they are sometimes able to obtain.

* * * * * * *

Reading, April 5th, 1875.

LUNAR-MONTHLY RAIN-FALL IN THE UNITED STATES.

By Pliny Earle Chase, Professor of Physics in Haverford College.

(*Read before the American Philosophical Society, April* 16, 1875.)

When the Meteorological Department of the Signal Service Bureau was first organized, I believed that the extent of territory embraced by the observations would soon furnish material for useful generalizations, in respect to the importance of climatic influences which many regard as either problematical, or wholly insignificant.

If any considerable improvement in our present system of weather forecasts should ever become possible, it will doubtless be brought about by a fuller understanding of cyclical changes. Howard and Sabine long ago showed that barometric pressure and magnetic force are sensibly affected by the moon, and the cumulative effect of undulations is such that the daily atmospheric tides, though singly of small magnitude, may, by regular succession, lead to such blendings of currents as will produce cyclical winds and storms. By my numerous comparative investigations I have shown that, while there is a great discrepancy in the forms of the lunar rain curves at different stations, the discrepancy is no greater than is found in the solar curves. I have also shown that there is a likeness between the curves for different independent periods, at the same station, which cannot be attributed to chance, such likeness being most striking, and the inflections of the curves being greatest where the lunar-tidal forces are strongest.

Any normal lunar, or planetary, wave-producing influence may be greatly obscured by local or accidental disturbances. The daily announcements of "probabilities" often seem to fail in a given locality, when the weather map shows that they are wonderfully verified in an entire region. So a lunar disturbance which would ordinarily bring rain, may be marked by cloud or wind at some stations, while, if we had reports from the entire district, we should find a general prevalence of rain. We may, therefore, look for results from observations at a large number of stations, extending over only a few years, analogous to those which would be shown in a long series of years, by the observations at a single station in the same district.

The influence of the Rocky Mountains upon our storms has been well known since the days of Redfield and Espy. The intersections of normal winds, near the base of those mountains, as well as the analogous intersections which occur in the West Indian birthplace of tornadoes, I have pointed out in a previous paper. In neighborhoods where there is a natural tendency towards a blending of currents, cumulative tidal influences may be supposed to have a special efficiency.

Influenced by these views, I have examined the morning weather maps for the past three years, tabulating, in accordance with the moon's age, both the number of reporting stations and the reported rain-fall upon

each map. I then divided the total rain-fall upon each day of the lunar month by the total number of stations reporting for the corresponding day, and took successive differences between the resulting averages, by Airy's method. The normals thus deduced are given in the accompanying table, together with the normals for various local curves. The curve deduced from 43 years' observations at Philadelphia, covers a longer period than any other to which I have had access in the United States, and its striking resemblance to the Signal Service curve is shown by the diagram. The resemblance is the more significant in view of the fact that the periods represented by the two curves are entirely independent. The flexures in the Philadelphia curve average about $1\frac{3}{8}$ days earlier than those of the general curve. On the hypothesis of cumulative tidal undulations, this would represent a daily difference of $1\frac{23}{45}$ hours, or $22\frac{2}{3}°$, a difference corresponding to disturbances originating in our Western territories.

Occasional breaks in my series of weather maps, the interference of storms with the transmission of reports, and other causes, combine to render these results imperfect, but their indications are of such a character as to convince me that a careful study of the full returns, which are forwarded thrice a day to the Signal Service Bureau, would lead to the discovery of important laws governing the lunar influence at various seasons of the year, at various periods of the day, and in various sections of the country.

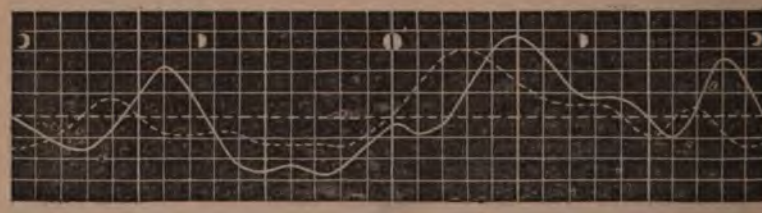
Lunar-Monthly Rain-fall, from Observations of Signal Service Bureau, and at Local Stations.

Lunar Day.	March, 1872 to Sept. 1873.	Sept. 1873 to April, 1875.	March, 1872 to April, 1875.	Philadelphia, 1825 to 1868.	San Francisco, 1849 to 1872.	Barbadoes 1847 to 1873.	Lisbon, 1854 to 1870.
1.....	105	96	100	93	97	90	106
2.....	106	88	96	94	97	79	106
3.....	101	86	94	97	94	77	99
4.....	99	87	92	102	92	84	90
5.....	98	94	96	103	96	89	85
6.....	104	104	103	100	104	88	83
7.....	111	110	111	97	107	85	84
8.....	106	108	107	96	108	82	89
9.....	97	102	97	96	107	86	93
10.....	85	94	89	96	103	93	98
11.....	93	84	87	95	97	99	105
12.....	100	79	88	94	99	106	118
13.....	95	81	87	94	110	110	128
14.....	87	87	87	94	125	107	126
15.....	87	97	93	96	138	98	118
16.....	91	103	98	100	134	93	117
17.....	87	102	96	106	115	96	126
18.....	87	105	97	113	105	103	135

Lunar-Monthly Rain-fall, from Observations of Signal Service Bureau, and at Local Stations—CONTINUED.

Lunar Day.	March, 1872 to Sept. 1873.	Sept. 1873 to April, 1875.	March, 1872 to April, 1875.	Philadelphia, 1825 to 1868.	San Francisco, 1849 to 1872.	Barbadoes 1847 to 1873.	Lisbon 1854 to 1870.
19.....	101	113	107	115	104	104	135
20.....	117	115	116	113	96	104	124
21.....	127	112	119	108	85	104	106
22.....	123	107	114	104	83	109	85
23.....	109	105	107	102	86	116	68
24.....	102	107	104	102	88	121	62
25.....	105	104	104	99	89	125	67
26.....	104	98	99	96	86	123	77
27.....	94	98	95	98	81	116	86
28.....	89	109	100	101	85	108	91
29.....	94	118	113	99	93	105	93
30.....	100	111	106	95	96	100	100

In the diagram each vertical space represents .05 of the mean rainfall; each horizontal space, a lunar day. The curves begin and end on the day of new moon. The Signal-Service curve for three years is the unbroken line; the Philadelphia curve for 43 years, the broken line.



Stated Meeting, January 1, 1875.

Present, 14 members.

Vice-President, MR. FRALEY, in the chair.

A letter accepting membership was received from Rawson W. Rawson, Esq., Governor of Barbadoes, dated Government House, Nov. 24, 1874.

Letters of acknowledgment were received from Royal In-

stitution, London, Dec. 2, 1874, (92); the Chemical Society, London, (92); the Society of Antiquaries, London, Dec. 8, 1874, (92; wanting 88); Mr. J. D. Cox, Toledo, Ohio, Dec. 24, 1874, (92); the Anthropological Institute of Great Britain and Ireland, London, 4 St. Martin's Place, W. C., Dec. 1, 1874, (92).

Letters requesting (62 and 88) missing numbers of the Proceedings were received from the Royal Geographical Society, London, 1 Saville Row, Burlington Gardens, W., Dec. 3, 1874.

A letter respecting publications for 1875 was received from Putnam & Sons, Fourth Avenue and Twenty-third street, New York, Dec. 17, 1874, for Amherst College.

A letter from A. H. Barclay, President, Rantoul Literary Society, Rantoul, Champaign County, Ill., Dec. 26, 1874, acknowledging receipt of (92) Proceedings and giving an account of the progress of that Society was read.

Donations for the Library were received from the Natural History Society at Emden, Royal Academy at Brussels, Geographical Society at Paris, Rèvue Politique, editors of London Nature, Boston Natural History Society, Worcester County Medical Association, Franklin Institute, editors of Penn Monthly, and the U. S. Department of the Interior.

Prof. Frazer exhibited a new and convenient retort for the manufacture of oxygen; a hollow cone of copper plate, fitting tightly down upon a short conical ring of copper plate, mounted upon a disc or base of the same, and forming a box to receive the residuum. Plaster of Paris is run into an outside groove to lute the joint. The instrument is cleaned with speed and ease; the resistance is so slight as to render an explosion little dangerous. Prof. Frazer claimed for it the merit only of being a convenient modification of Prof. Morton's apparatus.

Mr. Briggs described an explosion at Kirkbride's Hospital, by which the engineer of that institution was killed, although connection was made through a pipe 80 feet long.

He thought experimenters should take warning by the frequency of these accidents. Prof. Morton, after three explosions, made habitual use of a water trap.

Prof. Frazer then read a paper in defence of Prof. Tyndall, entitled "Criticism of the Belfast Address of Prof. Tyndall."

Prof. Chase communicated additional results respecting the Magnitude of Gravitating Waves. (See page 344.)

The report of the judges and clerks of the annual election was then read, by which it appeared that the following officers for the ensuing year had been elected:

For President,

George B. Wood.

For Vice-Presidents,

John C. Cresson, Isaac Lea, Frederick Fraley.

For Secretaries,

E. Otis Kendall, John L. LeConte, Pliny E. Chase, J. P. Lesley.

Councilors for three years,

Daniel R. Goodwin, Eli K. Price, W. L. W. Ruschenberger, Henry Winsor.

For Curators,

Joseph Carson, Charles M. Cresson, Hector Tyndale.

For Treasurer,

J. Sergeant Price.

J. P. Lesley was nominated as Librarian.
Pending nominations 764, 765 were read.
New nomination 766 was read.
And the meeting was adjourned.

Stated Meeting, January 15, 1875.

Present, 15 members.

MR. FRALEY, Vice-President, in the chair.

A letter resigning membership on account of his inability to attend the meetings was received from Mr. Lloyd P. Smith, of Germantown, Philadelphia.

A letter requesting Proc. No. 88 was received from the London Horticultural Society, per Prof. Asa Gray, Dec. 31, 1875.

A letter requesting Proceedings January–June, 1872, pp. 225–232, was received from the Boston Athenæum, dated Jan. 8, 1875.

A letter acknowledging Proceedings 81 to 92 and asking for the preceding numbers of the set, was received from Mr. R. S. Williamson, dated San Francisco, Jan. 2, 1875.

Letters of acknowledgment were received from the Agricultural Society at Lyons, Oct. 30, 1875, (Proc. 1 to 91, wanting 5, 17, 21, 23, 26, 29 to 31, 34, 63 and 64); and from the London Statistical Society, London, Dec. 14, 1874 (92).

A letter of Envoy was received from the Royal Society of Victoria, dated Melbourne, March 10, 1874.

Circular letters were read from the K. K. Geological Institute, Vienna, respecting its Twenty-fifth Anniversary Festival, Jan. 5, 1875; from the Royal Belgian Academy respecting a monument to M. Quetelet; from the Canadian Parliamentary Companion; from the Linnean Society at Lyons; and from the Congrès Internationale des Américanistes.

Donations for the Library were received from the Royal Society at Victoria; The German Geological Society; the Physico-Medical Society at Erlangen; the Zoölogische Garten; the Flora Batava; Agricultural Society at Lyons; Nouvelles Météorologiques, and Revue Politique at Paris; Royal Astronomical Society, Chemical Society, Victoria Institute, and Editors of Nature; the Cornwall Polytechnic Society; American Journal of Science, New Haven; New York Ly-

ceum of Natural History; Journal of Pharmacy; U. S. Survey of the Territories; Department of the Interior; and the Editors of "the Western."

Mr. Wharton called attention to the fact that there seemed to be a movement on foot to favor the inauguration of another Arctic Expedition; suggesting that the Society should take the initiative by proposing to the Secretary of the Navy a plan which should involve the use of the stores of the Polaris.

Mr. Delmar, by invitation, read a memoir on the Progress and Statistics of Spain, previous to and since 1855, the date of the Great Reform laws. (See page 301.)

On motion, Mr. Lesley was chosen Librarian, and the standing committees were nominated and elected for the ensuing year:

Finance,

Mr. Fraley, Mr. E. K. Price, Mr. Marsh.

Publication,

Dr. LeConte, Dr. Brinton, Dr. H. Allen, Dr. C. M. Cresson, Mr. Tilghman.

Hall.

Gen. Tyndale, Mr. E. Hopper, Mr. S. W. Roberts.

Library.

Dr. Coates, Mr. E. K. Price, Dr. Carson, Dr. Krauth, Mr. Whitman.

Pending nominations 764, 765, 766 were read.

Pending nominations 764, 765 were balloted for.

On motion the reading of the list of members was postponed.

On scrutiny of the ballot boxes by the Presiding Officer, the following were declared duly elected members of the Society:

Dr. Jared P. Kirtland, Ohio.

Mr. John B. Pearse of Philadelphia.

And the meeting was adjourned.

Stated Meeting, February 5, 1875.

Present, 13 members.

Vice-President, MR. FRALEY, in the chair.

A letter enclosing his carte de visite photograph for the album was received from Dr. Robert Peter, dated Lexington, Ky., Jan. 28, 1875.

A letter of acknowledgment (92) was received from the Rantoul Literary Society, Jan. 26, 1875.

A letter of envoy was received from Mr. Alex. Agassiz, dated Cambridge, Jan., 1875, stating that missing numbers of his father's works, for the Society's set, were sent by express to supply the deficiency, and requesting the return of any duplicate parts in the possession of the Society.

Donations for the Library were received from Dr. Max. Marques de Carvalho, of Rio Janeiro; Mr. F. W. C. Trafford, of Zurich; the R. Belgian Academy; the Editors of Revue Politique, and Nature, and the British Trade Journal; the Royal Astronomical Society; Mr. Alex. Agassiz, of Cambridge, Mass.; the Franklin Institute; Editors of Penn Monthly, Medical News, Journal of the Medical Sciences, Journal of Pharmacy, and the American Chemist; Mr. H. C. Carey; the Chief of Engineers of the United States; and the Geological and Agricultural Survey of Texas.

The death of Mr. Nathaniel Bradstreet Shurtleff, at Boston, Oct. 17, 1874, aged 63, was announced by the Secretary.

The death of Mr. Francis Kiernan, F.R.S., Dec. 31, 1874, was announced by the Secretary.

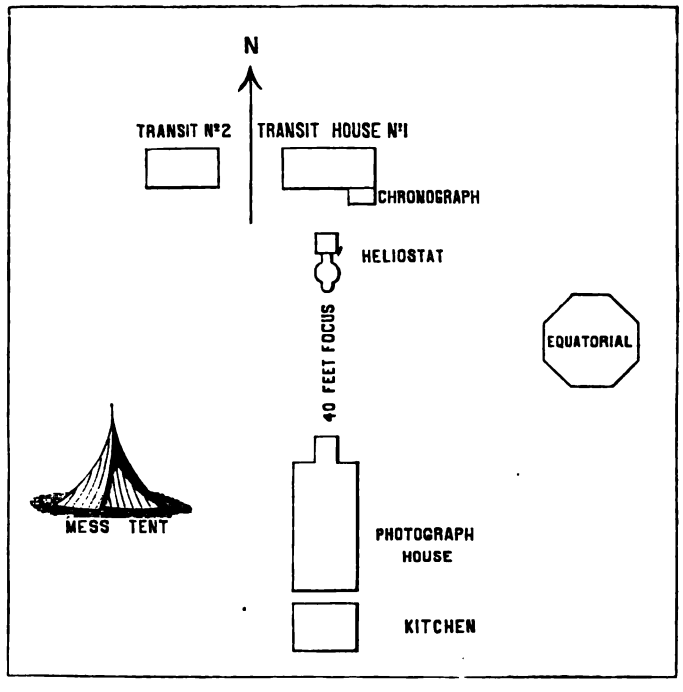
Mr. Coleman Sellers announced that he was prepared to read an obituary notice of the late Joseph Harrison at the next meeting.

A letter was received from Daniel B. Smith, of Germantown, Philadelphia, quoting a letter from Mrs. Davidson, dated Nagasaki, Dec. 10, 1874, describing the scene of observations at the time of transit:

TO THE AMERICAN PHILOSOPHICAL SOCIETY:

I have this morning received a letter from Prof. Davidson's wife, dated Nagasaki, Dec. 10, 1874, which I transcribe for the Society:

"We were 24 days on the passage over and remained one week in Yokahama and Yedo, before taking the steamer for Nagasaki. No time was to be lost, and at 12 o'clock, on the day of our arrival they had 30 coolies building the road up to the side of the observatory, which is 300 feet high, and about a mile and a half south of the town. They have been working night and day ever since, feeling somewhat hurried. You can imagine with what anxiety every cloud was watched for several days before—which had been hazy or cloudy in the mornings—blowing over by midday.



The preceding night was clear and beautiful until day-break, when clouds began rapidly to form, breaking away again about 7½, and clouding over again by 9½. The observers remained all night on the hill and the others were at their post by 7½ o'clock. I went up in a sedan chair (carried by four Coolies), and we were all at our posts of duty by ten o'clock and as the time draws nearer, you can imagine our suspense. In my husband's observatory (the large equatorial), just before the computed time, the sun seemed to be breaking through the clouds and all was in readiness; George, the largest boy holding the chronometers up to his father's eye and ear; and I seated (where I would see my husband's face,) with book and pencil in hand, with closed doors and perfect silence, save the regular

beats of the clock and chronometers. It was almost a solemn moment. The sun broke forth with one gleam—I was almost startled to my feet with the shout of "*Commence*," given by my husband, as warning to the Photographers as the instant was about to arrive. In a few seconds he gave an exclamation of delight and the first contact was accomplished and duly recorded. After giving us an instantaneous peep, observations were kept up till the next critical moment of the second contact; the sun growing less bright, but still bright enough for observations, the second contact was seen and further observations as the body was passing over the sun—growing thicker and thicker and leaving scarcely a hope for the third contact and also for the fourth which were not visible and then the whole thing was over, not wholly successful, but by no means unsuccessful, and I think my husband is pretty well satisfied; he certainly feels that they made the most of the situation, everything working well and only failed on account of the weather.

One thing strikes me as very wonderful—of course the exact spot on the sun's limb where the contact should appear was only known by computation from our previous data, and under such large magnifying power, which took in only about 5½ diameters of Venus, one minute of an arc would have been fatal. Mr. D. had gone over his calculations several times and that same morning had gone over them to satisfy himself, and then pointed his instrument and sure enough there came Venus, right in the centre of his pointing, 3½ minutes later than the English computed time, and 1½ earlier than the American time.

I hope the Society will think this account worthy of an early publication.

Respectfully,

DANIEL B. SMITH.

Germantown, 1*st mo.*, 29*th*, 1875.

The letter of Mrs. Davidson was ordered to be published as soon as possible.

The Secretary presented a communication, entitled "Notes on the Geology of West Virginia," No. II., by Jno. J. Stevenson, Prof. of Geology, University of N. Y., and explained the author's work in that region, in connection with the proposed occupation of a new district in Southwestern Pennsylvania by the Geological Survey of Pennsylvania. (See page 370.)

Mr. Fraley reported the receipts, and payment to the Treasurer, of $152.79, being the last quarterly payment of the interest on the Michaux Legacy.

The following report of the Trustees of the Building Fund of the A. P. S. was read by its Treasurer, Mr. Marsh

"U. S. 5-20 Bond	$1,000 00
"Schuylkill Nav. Co. Boat and C. loan	500 00
"Pennsylvania State 6 per cent. bonds	1,500 00
"Philadelphia City " "	6,900 00
"Stock of the McKean and Elk Land and Improvement Co., 200 shares, subscribed	1,000 00
"Cash	3 91
Total	$10,903 91

Signed—"by order of the Trustees.

BENJAMIN V. MARSH, Treasurer."

PHILADELPHIA, FEB. 5, 1875.

In the absence of members of the Hall Committee, Mr. Fraley stated, that the city authorities had undertaken to make alterations in the lower stories of the Hall of the Society, in view of another court room; and that the Insurance Companies had been consulted on the subject, and had given permission to make alterations and repairs. At his request the Secretary read from the minutes of July 17, and Aug. 21, 1863, the resolutions passed by the Society respecting the lease of said stories by the city.

Mr. J. S. Price expressed his conviction that danger to the Society's Cabinet and Library from fire was imminent; the Secretary adding his testimony to that effect.

On motion, it was then unanimously

Resolved, That the subject of the city tenancy of the two lower stories of the Hall of the Society and the proper protection of the property, from fire, or other casualty, be referred to the Hall Committee, the Presiding Officer, Mr. Fraley, and the Treasurer, Mr. Price, with power to take such order as they may think proper in the premises.

And the meeting was adjourned.

Stated Meeting, February 19, 1875.

Present, 18 members.

Vice-President, MR. FRALEY, in the chair.

Letters of acknowledgment were received from the Imperial Academy at Vienna, (90, 91), Herr Tunner, Leoben, (90, 91), Dr. Rokitansky, Vienna (90, 91), Geological Society

at Dresden (90, 91), the Society at Freiburg i. Br. (90, 91), the Society at Emden (90, 91), the Society at Geneva (89, 90, 91, XV. i.), the Society at Berne (89), and the Society at Newcastle-on-Tyne (92).

Letters of envoy were received from the Natural History Societies at Freiburg, Emden, Marburg, Berne, and Geneva.

A circular letter was received from the Linnéan Society, of Normandy, concerning a proposed statue to Elie de Beaumont at Caen.

A circular letter was received from Mr. W. Whittaker, dated Geological Survey Office, Jermyn Street, London, Jan. 30, 1875, on the part of a proposed new Geological Magazine, entitled Geology, Mineralogy, and Palæontology, British and Foreign.

Donations for the Library were received from the Prag Observatory; Vienna Geological Institute; Royal Prussian Academy; German Geological Society; Dresden Geological Society; Natural History Societies at Freiburg, Emden, Marburg, Schaffhausen, and Geneva; the Anthropological and Geographical Societies; Editors of the Annales des Mines and Révue Politique, at Paris; the Meteorological Committee of the Royal Society, and Nature, London; Prof. J. D. Dana; Silliman's Journal; American Chemist; Franklin Institute; Mr. John McArthur; McCalla & Stavely; Medical News and Library; American Pharmaceutical Association; the Geological Survey of Pennsylvania; Department of the Interior, U. S.; and Mr. A. R. Roessler.

An obituary notice of Joseph Harrison, Jr., was read by Mr. Coleman Sellers. (See page 347.)

An obituary notice of Charles B. Trego, was read by Mr. Sol. W. Roberts. (See page 356.)

The minutes of the last meeting of the Board of Officers and Members in Council were read.

Pending nominations, Nos. 766, 767, 768, and new nominations, Nos. 769, 770, 771, 772, 773, 774, and 775, were read.

Mr. Roberts reported the improvements made and to be made in the furniture of the Hall.

Mr. Fraley reported progress in negotiating a more satisfactory understanding with the city authorities, respecting the tenancy of the lower stories of the Hall building.

On motion, the Secretaries were authorized to place the new Geological Magazine, London, on the list of correspondents to receive the proceedings, if they thought proper to do so.

On motion of Mr. Price, the Committee on the Hall were authorized to obtain a new table, to re-cover the president's desk, and see to a better condition of the carpeting and furnishing of the room in which the members meet.

And the Society was adjourned.

Stated Meeting, March 5, 1875.

Present, 10 members.

MR. ELI K PRICE, in the chair.

A letter accepting membership was received from Mr. J. P. Kirtland dated Cleveland, Ohio, Feb. 22, 1875.

A letter of acknowledgment (93) was received from the U. S. Naval Observatory, dated March, 1875.

A letter of acknowledgment (93) was received from the Rantoul Literary Society, Rantoul, Ill., Feb. 27.

A letter from Mr. S. P. Langley, Directory of the Allegheny Observatory, requesting the donation of Transactions of the A. P. S. was referred to the Publication Committee.

Donations for the Library were received from the Royal Academy at Brussels; Editors of the Révue Politique; Royal Astronomical Society; and London Nature; Essex Institute; Editors of Penn Monthly; Pharmaceutical Association; Medical News and Library; and Judge Brewster, of Philadelphia; Engineer Department and Secretary of War, Washington; Wisconsin Historical Society; Wisconsin Academy of Sciences and Arts; and Editors of the Western.

The death of Sir Charles Lyell was announced by the Secretary, at London, Feb. 24, 1875, aged 78 years

The death of Dr. Geo. W. Norris, at Philadelphia, March 4, 1875, aged 67 years, was announced by Mr. J. S. Price.

Mr. Cope read a paper by the title, "A Synopsis of the Vertebrata of the Miocene of Cumberland County, New Jersey." (See page 361.)

Dr. Cresson exhibited a map or diagram arranged on a vertical scale to represent the five coal beds mined at Ellengowan, near Mahanoy City, representing the thickness and subdivisions of each bed; and on a horizontal scale to exhibit the proportions of the various chemical elements obtained by analysis. Of the mammoth bed, the uppermost group of four benches is, at Ellengowan, separated from the middle group of three benches by 150 yards of rock, and the middle from the lower group of four benches by an equal distance, all three groups lying together, without the intervention of rock measures, in the neighboring collieries on each side; the total thickness of coal remaining always about the same.

Dr. Cresson exhibited and explained an American modification of Bunsen's apparatus for determining the specific gravity of any gas, and the obstacles to accuracy of the investigation when the given gas was either much heavier or much lighter than the common air into which it escaped.

Prof. Chase, being referred to, said that he had been requested by Dr. Cresson to experiment with the instrument in order to discuss its eccentricities, and had used the city gas, obtaining various curves of velocity of exit, when the uppermost and lowermost, or the two, or three, or other numbers of inches at the top or bottom of the tube were paired against each other; but without entirely satisfactory results.

He considered it probable that the causes of irregularity fell under three heads, viz.: 1st, the difference of density of the medium into which the fine jet of gas issued (through a microscopic hole in platinum foil); 2d, the vertical spiral forms into which the currents must be thrown; and 3d, friction, varying with condensation inside the instrument,

whenever the general temperature of the laboratory falls. To this latter cause he ascribed differences of results obtained in the morning and evening, amounting to twenty per cent. He thought that under favorable circumstances and with requisite care, an approximation to accuracy can be made within two per cent., and much closer than with the Bunsen instrument.

Professor Frazer communicated the fact of the discovery of titanic iron, in the form of a perfect crystal and of unusual size, half an inch on a side, associated with chlorite, in chromic iron, at Frank Wood's Mine, in Lancaster County, Pa. The specimen is in the possession of Mr. Tyson, near King of Prussia, Chester County, Pa. A small portion of the crystal was submitted to the blowpipe by Prof. Brush. (The specimen is mentioned in Dr. F. A. Genth's Report on the Mineralogy of Pennsylvania, Reports of Progress of the Second Geological Survey, 1874.)

Prof. Chase read a letter from Gov. Rawson, of Barbadoes, in which he writes that he expects to obtain the appointment, by Government, of a salaried officer, intrusted with the duty of continuing the meteorological observations at Barbadoes, the importance of which is made the greater by the fact that the island is near the hypothetical cradle of the Atlantic cyclones and tornadoes of the Gulf of Mexico.

Prof. Frazer described some microscopic sections of trap dykes on the Mesozoic red sandstone of Pennsylvania and Connecticut. He had taken specimens from the vicinity of Gettysburg, both as slides and fragments, to New Haven, and compared them with similar slides and fragments of the Connecticut traps in the possession of Mr. E. S. Dana. There were fine grained greenish dolerites exactly alike in both localities. Coarse-grained gray rock, which in fragments seemed identical, under the microscope showed differences between the Connecticut and Pennsylvania varieties; that of the former being merely a coarse-grained dolerite, while that of the latter was a true syenite. He said:—

During a recent trip to New Haven, I had the pleasure of examining the

very large collection of microscopic slides of the traps of the Mesozoic sandstone in the vicinity of that town.

Mr. Dana exhibited to me fragments of the traps, which when compared with the fragments which I had brought with me seemed to be identical lithologically so far as the eye, aided by a magnifying glass, could determine. There were two varieties of this trap which had been considered in my work essentially distinct, viz.: the doleritic and the syenitic. Both these varieties are represented within a small area in the immediate environs of Gettysburg, and even bear the appearance of running together (to judge from a rough guess from the topography). Now the finer-grained dolerite is of green color, and the specimens from New England, and those I took with me, showed under the microscope, and with the polarizer alone, the following mineral constituents. Pyroxene (Augit), plagioclastic feldspar, magnitite (in fine grains and irregular masses), and chrysolite. Mr. Hawes, of the Mineralogical laboratory, assures me that he has frequently found quartz in these dolerites.

The coarse-grained rock (both the specimen from Gettysburg and that from Connecticut,) is gray and granular, consisting of black and white crystals so mingled as to produce the familiar granite color to the eye. In fact the rock from Gettysburg is called "Gettysburg Granite." It was absolutely impossible to distinguish the fragments of this rock from the localities apart, yet under the microscope and the single Nicol the effect was very different. The Connecticut variety showed the same constituents as the other traps—was in fact a coarse dolerite; whereas that from Gettysburg showed the characteristic dichroism of hornblende, and also under a high magnifying power crystals of biotite.

In the specimen which I took with me to New Haven, there were no cleavage planes to absolutely settle the character of the supposed hornblende, but in others in my possession this was very marked and settles definitely the question of the occurrence of syenite in the Mesozoic sandstone.

Mr. Dana warns me of a possible error in this conclusion, viz.: that the mass from which I took my slides was only a bowlder—not in place. This would be a very serious objection were it not for the absolute identity of the rock in the immense masses of slab formed rock, from the quarry which supplies the tombstones and the walls of our national cemetery, as well as cubic roods of rock in Culp's Hill, Great Round Top, Granite Spur, and Devil's Den—localities which must ever remain familiar to us as connected with the history of one of the decisive battles of the world.

Besides this, as the Gettysburg locality lies miles south of the extreme southern limit of the drift, there would seem to be no adequate theory to account for such transportation.

In order to set at rest this doubt and decide this question finally, further sections will be made from rock without doubt *in situ* and the results communicated to the Society.

Pending nominations, Nos. 766 to 776, and new nominations, Nos. 777, 778 were read.

On motion of Prof. Frazer, it was

Resolved, That the Hall Committee be requested to consider the propriety of placing in the Society's rooms one of the instruments of the American District Telegraph Company, and the Treasurer be authorized to pay $18.00 as the annual rental of the same.

And the Society was adjourned.

Stated Meeting, March 19, 1875.

Present, 13 members.

Vice-President, Mr. Fraley, in the chair.

Photographs of Prof. Sadtler and Prof. Thomson, of the University of Pennsylvania, were presented for insertion in the album.

Letters of acknowledgment were received from the Literary and Philosophical Society of Liverpool, dated Jan. 25 (XIV., XV., i., 90, 91, 92); and Smithsonian Institution (90, 92).

A letter was received from the New Jersey Historical Society, Newark, March 12, requesting that deficiencies in their set of Proceedings and Transactions A. P. S. be supplied (Proc. I., II., III, 77. Transactions, all but the First Series III., i. Cat. I).

A letter was read from Mr. Wm. Holden, Librarian of the Ohio State Library, desiring to exchange copies of the Geological State Survey for Dr. Wood's and Mr. Cope's memoirs on the Arachnidæ and Myriopoda, in the Transactions and Proceedings of the American Philosophical Society.

Letters of envoy were received from the Austrian Academy, Sep. 30, 1874; the St. Petersburg Physical Central Observatory, Jan., 1875; the Greenwich Observatory, Feb. 19, 1875; the Literary and Philosophic Society, of Liverpool, Jan. 28,

1875; and Department of the Interior, Washington, March 10, 1875.

Donations for the Library were received from the Austrian Academy of Sciences; Belgian Academy of Sciences Editors of the Révue Politique; London Chemical Society; Royal Institution; Editors of Nature; Society of Arts and Institutions in Union; the (Travancore Observatory) Maharaja, of Travecore; Silliman's Journal; Prof. O. C. Marsh; and the Department of the Interior, U. S.

The decease of Nathaniel B. Browne, of Philadelphia, March 13, aged 55 years, was announced by Mr. E. K. Price, and on motion Mr. Robert Patterson was appointed to prepare an obituary notice of the deceased.

Mr. Frazer described and discussed the origin of certain beds and belts of limonite in Southern Pennsylvania, with the help of a colored map of York and Adams County, and a geological map of Pennsylvania. Dr. König and Mr. Lesley spoke on the same subject. (See page 364.)

Pending nominations 766 to 779 were read.

On motion of Dr. Cresson, for the Publication Committee, an additional appropriation of one hundred dollars was made to defray the expense of the illustrations of Dr. Allen's Memoir now being printed in the Transactions.

General Tyndale presented the request of the Directors of the Franklin Insurance Company that the Society permit Mr. Waugh to make for them a copy of the portrait of Franklin in the possession of the Society. On motion of Mr. Chase, the curators were authorized to permit such copy to be made, taking the usual and proper precautions for the security and safe return in good order of the picture.

On motion of Dr. Cresson another album volume similar to the one now filled with portraits of the members of the Society was ordered to be purchased.

And the meeting was adjourned.

NOTE BY DR. CARSON.

The picture of Franklin in the possession of the American Philosophical Society is by Martin, of London, a copy by himself of a picture painted

by him, of Dr. Franklin, for William Alexander's grandson, Henry J. Williams, Esq., of Philadelphia. The copy was placed by Franklin, about 1765, in the keeping of the Supreme Executive Council of Pennsylvania, and upon the abolition of that body at the time of the Revolution came into the hands (probably) of Mr. Peale when his Museum was in the Hall of the American Philosophical Society, and was by him there left at the removal of the Museum to the State House. This statement is made to Dr. Carson by Mr. Williams, who has the original.

Stated Meeting, April 2, 1875.

Present 15 members.

MR. ELI K. PRICE, in the chair.

Letters of envoy were received from the Meteorological Office of the Royal Society, London, March, 1875; and the U. S. Department of the Interior, Washington, March 19, 1875.

A letter from Harvard College Library was received requesting a missing signature, pages 225–232 of the Proceedings, Vol. XIII.

Donations for the Library were received from the Prussian and Belgian Academies; the Editors of the Révue Politique and Nouvelles Meteorologiques; the Astronomical Society; Meteorological Committee of the Royal Society; the Cobden Club; and the Editors of "Nature;" the Chief Geologist of Canada; Essex Institute; College of Pharmacy; Academy of Natural Sciences; and Mr. Delmar, of Philadelphia; the U. S. Department of the Interior; and U. S. Department of Engineers; and the Academy of Sciences at St. Louis.

The death of Dr. D. Francis Condie, March 21, 1875 aged 9, was announced by Dr. Bridges.

Pending nominations Nos. 766 to 779, and new nomination 780 were read.

And the meeting was adjourned.

Stated Meeting, April 16, 1875.

Present 16 members.

Dr. Carson in the chair.

Letters of acknowledgment were received from the Natural History Society at Wiesbaden, the British Association, and the American Ethnological Society in New York.

A letter of envoy was received from the Central Physical Observatory at St. Petersburg.

A letter was received from the Academy of Sciences of Chicago requesting the replacement of Proceedings of the American Philosophical Society lost by the fire. On motion, the request was granted.

A letter was received from the Department of the Interior, U. S. Bureau of Education, dated March 31, calling for information respecting the Library. On motion, referred to the Librarian.

Donations for the Library were announced from the Academies at Berlin and Bruxelles; the Societies at Görlitz, Wiesbaden, and Bonn; the Editors of the Annales des Mines, Révue Politique, and Nouvelles Meteorologiques; the Royal Institution; Editors of Nature; and Mr. Robert Twining; the Société Litèraire et Philosophique, Quebec; the Massachusetts State Board of Health; Silliman's Journal; State Geologist of New Jersey; American Journal of the Medical Sciences; Department of the Interior, U. S.; and editors of the Western.

The death of Dr. Andrew A. Henderson, at the U. S. Naval Laboratory, Brooklyn, N. Y., on the 5th inst, aged 59, was announced by Mr. Lesley. On motion, Mr. Lesley was requested to prepare an obituary notice of the deceased.

The death of Mr. John Henry Towne, of Philadelphia, at Paris on the 6th inst., was announced by Mr. Lesley. On motion Mr. Sol. W. Roberts was requested to prepare an obituary notice of the deceased.

Dr. LeConte read another communication from Dr. W.

J. Hoffman, dated Reading, April 5, 1875, respecting the Practice of Cremation among the Pàh-Utes, or Digger Indians, of California. (See page 414.)

Prof. Frazer read a communication on the composition of trap rocks and gave illustrations on a screen, from slices, with a lime light, and various powers of lens. (See page 402 and plates 1, 2, 3, 4.)

Mr. Chase communicated a comparison between the lunar-monthly rain-fall in the United States as indicated by the morning weather-maps for three years, and the Pennsylvania Hospital observations for 43 years. (See page 416.)

Mr. Lesley said that the members present might be interested in the fact that he had succeeded in obtaining a cross-section projection of the two azoic mountain ranges which once occupied Southeastern Pennsylvania, giving for the first time a correct explanation of the structural geology of the gneiss and mica-slate belt commencing at Easton, on the Delaware River, and passing through Philadelphia, Delaware, Chester, and Lancaster Counties toward Baltimore. The sharp synclinal at the soapstone quarries separates an anticlinal mass to the north from a broader anticlinal mass to the south. The axis of the latter passes through the Fairmount reservoir, in Philadelphia; and a careful collation and projection of the dips observed, (by Messrs. Young and Fagen, aids on the survey,) along the Reading Railroad track, up the west bank of the Schuylkill, upon a base line of vertical section transverse to the general strike, namely, N. 5° E,—S. 5° W. shows that the highest rock now seen in that synclinal originally rode over Fairmount at an altitude of about 15,000 feet; and over the northern anticlinal at an altitude of 10,000 feet. The dips of the northern anticlinal swing round from south by east to north in a regular curve, showing that the northern mountain mass declined rapidly eastward, that is towards Easton, where the whole of the azoic sinks beneath the New Red, of New Jersey. This mountain, dying down eastward, stopped the normal course of the Schuylkill from Reading to Chester; and the present

notable zigzag of the river towards the Northeast and then towards the Southeast is thus explained. The ancient drainage passed around the eroded east end of the mountain. For a good many years he had maintained the existence of these ancient Alpine ranges in early times, but without until now deducing the opinion from regularly compiled structural elements of observation.

Pending nominations Nos. 766 to 780 were read, and Nos. 766 to 779 balloted for, and the following persons declared duly elected members of the Society:

Mr. Wm. A. Ingham, of Philadelphia.
M. Viollet le Duc, of France.
Mr. John McArthur, Jr., of Philadelphia.
Judge Joseph Allison, of Philadelphia.
Mr. Edward Penington, of Philadelphia.
Dr. Henry Chapman, of Philadelphia.
Mr. Alexander Agassiz, of Cambridge, Mass.
Prof. Frederick Prime, Jr., of Easton, Pa.
Prof. S. P. Langley, of Allegheny City, Pa.
Mr. H. S. Hagert, of Philadelphia.
Prof. C. F. Chandler, of New York.
Mr. Rossiter W. Raymond, of New York.
Prof. Leonard G. Frank, of Philadelphia.
Mr. Wm. P. Tatham, of Philadelphia.

And the meeting was adjourned.

Stated Meeting, May 7, 1875.

Present, 20 members.

Vice-President, Mr. Fraley, in the Chair.

Letters accepting membership were received from Mr. Alex. Agassiz, dated Cambridge, Mass, April 20; Judge Joseph Allison, dated Philadelphia, April 21; Mr. John McArthur, Jr., dated Philadelphia, April 20; Prof. Leo. Geo. Frank, dated Philadelphia, April 19; Mr. H. S. Hagert,

dated Philadelphia, May 3; Mr. W. A. Ingham, dated Philadelphia, April 19; Prof. S. P. Langley, dated Allegheny, Pa., April 19; Prof. Frederick Prime, Jr., dated Lafayette College, Easton, April 19, and Prof. Rossiter W. Raymond, dated New York, April 24.

A letter of acknowledgment was received from the Royal Society, dated Edinburgh, Dec., 1874 (XIV. i. iii. Proc. 83-87).

A letter of envoy was received from the London Meteorological Office of the Royal Society dated April, 1875.

Donations for the Library were received from the Royal Academies at Berlin and Turin; the Observatories at Greenwich, Cape Town, and Oxford; the Geographical Society and Editors of Révue Politique at Paris; the Royal Geographical and Royal Astronomical Societies and Editors of "Nature" at London; and Literary and Philosophical Society, Liverpool; Natural History Society, of Northumberland, at Newcastle-on-Tyne; Royal Society and Royal Botanical Garden at Edinburgh; Royal Geological Society at Dublin; Essex Institute; Museum of Comparative Zoology, at Cambridge, Massachusetts; Boston Society of Natural History; American Antiquarian Society at Worcester; Silliman's Journal; Prof. J. D. Dana; Editors of the American Chemist; Columbia College School of Mines; New Jersey Historical Society; Editors of the Medical News and Penn Monthly; College of Pharmacy; Dr. C. M. Cresson; Mr. Lorin Blodget; the U. S. Coast Survey; U. S. Engineer Department; and U. S. Department of the Interior.

Dr. Barker exhibited the performance of his new arrangement of the galvanometer for lecture illustration, describing the successive contributions to its perfection made by Saxton, Poggendorf, Sir Wm. Thompson, President Morton, and Prof. Mayer.

A discussion followed on the galvanic currents in rocks, and the magnetism of the earth.

Mr. Blodget referred to a former communication to the Society on the subject of the vertical descent of air in the

case of the meteoric "Northers," and to similar views expressed by Professor Loomis at the last meeting of the National Academy at Washington, regretting that he had not had leisure to place all the facts which he had observed and gathered in support of his views before the Society.

Pending nomination No. 780 was read.

Mr. Fraley reported the receipt of the quarterly interest of the Michaux legacy, due April 1st, amounting, with the premium on gold, to $154.48.

And the meeting was adjourned.

Stated Meeting, May 21, 1875.

Present, 15 members.

Vice-President, Mr. Fraley, in the Chair.

A letter acknowledging the receipt of Proceedings 92 was received from the New Bedford Free Public Library.

Letters of envoy were received from the Asiatic Society of Japan, dated Yokohama, April 5; the United States Coast Survey office; the Norwegian University, Christiana; and Mr. H. Wheatland, Salem, Massachusetts, May 5, 1875.

Donations for the Library were received from the University of Norway; Dr. Boekh; the Royal Society at Göttingen; Royal Academy at Berlin; Horticultural Society, Berlin; Dorpat Observatory; Imperial Geological Institute, Vienna; Société Vaudoise, Lausanne; Editors of Révue Politique, Paris, and "Nature," London; Mr. H. Wheatland, Salem; Peabody Museum, Cambridge, Massachusetts; New Bedford Free Public Library; Prof. Dana, New Haven; Buffalo Society of Natural History; Editor of the American Chemist, New York; Department of the Interior, U. S.; and Mr. Winchell.

Letters requesting back numbers to complete a set were received from the Royal Academy, Berlin, and Trübner & Co.

Mr. Lesley described the changes made in the theoretical

geology of the country south of Lake Erie, suggested by the work of the New Geological Survey of Pennsylvania; the most important of these changes, namely, the adoption of an east and west strike for a northeast and southwest strike, being necessitated by the probability that most of the exposures of conglomerate throughout Warren, Venango, and Crawford Counties in Pennsylvania, and Cattaraugus and Chautauque Counties in New York, belong to a horizon 200 feet below that of the Great Conglomerate, No. XII, the base of the Productive Coal Measures.

Dr. Cresson referred to the discussion of thermo-electric currents at the last meeting to state his own opinion that it is not needful to have two metals, or an unhomogeneous mass of one metal for the exhibition of such currents. He had found water alone to be a sufficient medium for the production and exhibition of the phenomena under discussion.

The minutes of the last meeting of the Board of Officers and Members in Council were read.

Pending nomination, No. 780, and new nominations, No. 781 and 782 were read.

And the meeting was adjourned.

CONTRIBUTIONS FROM THE PHYSICAL LABORATORY OF THE UNIVERSITY OF PENNSYLVANIA.

No. I.

A NEW VERTICAL-LANTERN GALVANOMETER.

By George F. Barker, M.D., Professor of Physics.

(*Read before the American Philosophical Society, May 7th*, 1875.)

Desiring to show to a large audience some delicate experiments in magneto-electric induction, in a recent lecture upon the Gramme machine, a new form of demonstration galvanometer was devised for the purpose, which has answered the object so well that it seems desirable to make some permanent record of its construction.

Various plans have already been proposed for making visible to an audience the oscillations of a galvanometer needle; but they all seem to have certain inherent objections which have prevented them from coming into general use. Perhaps the most common of these devices is that first

used by Gauss in 1827, and adopted subsequently by Poggendorff and by Weber, which consists in attaching a mirror to the needle. By this means, a beam of light may be reflected to the zero point of a distant scale, and any deflection of the needle made clearly evident. The advantages of this method are :—1st, the motion of the needle may be indefinitely magnified by increasing the distance of the scale, and this without impairing the delicacy of the instrument; and 2d, the angular deflection of the needle is doubled by the reflection. These unquestioned advantages have led to the adoption of this method of reading in the most excellent galvanometers of Sir William Thomson. While therefore, for purposes of research, this method seems to leave very little to be desired, yet for purposes of lecture demonstration it has never come into very great favor; perhaps because the adjustments are somewhat tedious to make, and because, when made, the motion to the right or left of a spot of light upon a screen fails of its full significance to an average audience.

Another plan is that used by Mr. Tyndall in the lectures which he gave in this country. In principle, it is identical with that employed in the megascope; *i. e.*, a graduated circle over which the needle moves is strongly illuminated with the electric light, and then by means of a lens a magnified image of both circle and needle is formed on the screen. The insufficient illumination given in this way, and the somewhat awkward arrangement of the apparatus required, have prevented its general adoption.

A much more satisfactory arrangement was described by Professor Mayer in 1872,* in which he appears to have made use, for the first time, of the excellent so-called vertical lantern in galvanometry. Upon the horizontal plane face of the condensing lens of this vertical lantern, Mayer places a delicately balanced magnetic needle, and on each side of the lens, separated by a distance equal to its diameter, is a flat spiral of square copper wire, the axis of these spirals passing through the point of suspension of the needle. A graduated circle is drawn or photographed on the glass beneath the needle, and the image of this, together with that of the needle itself, is projected on the screen, enlarged to any desirable extent. The defect of this apparatus, so excellent in many respects, seems to have been its want of delicacy; for in the same paper the use of a flat narrow coil, wound lengthwise about the needle, is recommended as better for thermal currents. Moreover, a year later, in 1873,† Mayer described another galvanometer improvement, entirely different in its character. In this latter instrument, the ordinary astatic galvanometer of Melloni was made use of, an inverted scale being drawn on the inside of the shade, in front of which traversed an index in the form of a small acute rhomb, attached to a balanced arm transverse to the axis of suspension of the needle, and moving with it. The scale and index were placed in front of the condensing lenses of an ordinary lantern, and their

*American Journal of Science, III, iii, 414, June 1872.

†American Journal of Science, III, v, 270, April, 1873.

images were projected on the screen in the usual way by use of the objective. This instrument is essentially the same in principle as the mirror galvanometer; but it cannot be as sensitive as the latter, while it is open to the same objection which we have brought against this—the objection of unintelligibility. In the hands of so skillful an experimenter as Mayer, it seems, however, to have worked admirably.

It was a tacit conviction that none of the forms of apparatus now described would satisfactorily answer all the requirements of the lecture above referred to, that led to the devising of the galvanometer now to be described, which was constructed in February of the present year. Like the first galvanometer of Mayer, the vertical lantern, as improved by Morton,* forms the basis of the apparatus. This vertical lantern, as constructed by George Wale & Co., at the Stevens Institute of Technology, as an attachment to the ordinary lantern, is shown in the annexed cut, figure 1. Parallel rays of light, from the lantern in front of which it is placed, are received upon the mirror, which is inclined 45° to the horizon, and are thrown directly upward, upon the horizontal plano-convex lens just above. These rays, converged by the lens, enter the object glass, and are thrown on the screen by the smaller inclined mirror placed above it. The upper face of the lens forms thus a horizontal table, upon which water-tanks, etc., may be placed, and many beautiful experiments shown. To adapt this vertical lantern to the purposes of a galvanometer, a graduated circle, photographed on glass, is placed upon the horizontal condensing lens. Above this, a magnetic needle, of the shape of a very acute rhomb, is suspended by a filament of silk, which passes up through a loop formed in a wire, stretched close beneath the object glass, and thence down to the side pillar which supports this objective, where it is fastened by a bit of wax, to facilitate adjustment. The needle itself is fixed to an aluminum wire, which passes down through openings drilled in the scale glass, the horizontal lens, and the inclined mirror, and which carries a second needle near its lower end.† Surrounding this lower

FIG. 1.

*Jour. Frank. Inst., III, lxi, 300, May, 1871: Am. J. Sci., III, ii, 71, 153, July, Aug., 1871: Quar. J. Sci., Oct., 1871. In Duboscq's vertical attachment, which was advertised in his catalogue in 1870, the arrangement is similar, except that the beam received upon the mirror is a diverging one, and consequently the horizontal lens is of shorter focus. A total reflection prism, placed above the object glass, throws the light to the screen. The instrument gives a uniformly illuminated but not very bright field.

† After the new galvanometer was completed and had been in use for several weeks, I observed, in re-reading Mayer's first paper, a note stating that the idea had occurred to him of using an astatic combination consisting of two needles, one above the lens and the other below the inclined mirror—the two being connected by a stiff wire passing through holes in the condenser and the mirror. The plan of placing the coil round the lower needle does not seem to have suggested itself to him. Indeed, it does not appear that the arrangement he mentions was ever carried into practical effect.

needle is a circular coil of wire, having a cylindrical hollow core of an inch in diameter, in which the needle swings, and a smaller opening transverse to this, through which the suspension wire passes. In the apparatus already constructed (in which the upper needle is five centimeters long,) the coil is composed of 100 feet of No. 14 copper wire, and has a resistance of 0 235 ohm The accompanying cross section (Fig. 2,) of the vertical-lantern galvanometer as at present arranged, drawn on a scale of $\frac{1}{12}$, will serve to make the above description more clear. A is the needle, suspended directly above the scale-glass D, by a silk filament, passing through the loop B, close under the obj ctive C. This needle is attached to the aluminum wire *a b*, which passes directly through the scale-glass D, the condensing lens E, and the inclined mirror F at H, and carries, near its lower end, the second needle I. This needle is shorter, (its length is 2.2 centimeters,) and heavier than the upper one, and moves in the core of the circular coil J, whose ends connect with the screw-cups at K. This coil rests on the base of the lantern, enclosed in a suitable frame. It is obvious that when the instrument is so placed that the coil is in the plane of the magnetic meridian, any current passing through this coil will act on the lower needle, and, since both needles are attached to the same wire, both will be simultaneously and equally deflected. Upon the screen is seen only the graduated circle and the upper needle; all the other parts of the apparatus are either out of the field or out of focus. Moreover, the hole in the lens is covered by the middle portion of the needle, and hence is not visible. The size of the image is, of course, determined by the distance of the galvanometer from the screen; in class experiments, a circle 8 feet in diameter is sufficient; though in the lecture above referred to, the circle was 16 feet across, and the needle was fourteen feet long, the field being brilliant.

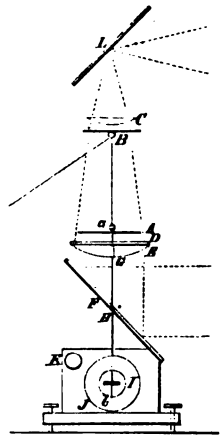


FIG. 2.

The method of construction which has now been described, is evidently capable of producing a galvanometer for demonstration, whose delicacy may be determined at will, depending only on the kind of work to be done with it. In the first place, the needles may be made more or less perfectly astatic, and so freed more or less completely from the action of the earth's magnetism, and consequently more or less sensitive. Moreover, an astatic system seems to be preferable to one in which damping magnets are used, since it is freer from influence by local causes; though, if desirable for a coarser class of experiments, the considerable distance which separates the needles in this instrument, allows the use of a damping magnet with either of them. In the galvanometer now in use, the upper needle is the stronger, and gives sufficient directive tendency to the system to bring the deflected needle back to zero quite promptly. In the experiments referred to below, the system made 25 oscillations per minute.

Secondly, the space beneath the mirror is sufficiently large to permit the use of a coil of any needed size. Since, therefore, the lower needle is entirely enclosed within the coil, the field of force within which it moves, may be made sensibly equal at all angles of deflection, as in the galvanometers of Sir Wm. Thomson. Hence the indications of the instrument may be made quantitative, at least within certain limits. The circular coil, too, has decided advantages over the flat coil, since the mass of wire being nearer to the needle, produces a more intense field. Were it desirable, a double coil, containing an astatic combination could be placed below the mirror, the upper needle, in that case, serving only as an index. The instrument above described has a coil three inches in diameter and one inch thick; the diameter of the core being one inch. Since its resistance is only about a quarter of an ohm it is intended for use with circuits of small resistance, such as thermo-currents and the like.

The results of a few experiments made with this new vertical-lantern galvanometer will illustrate the working of the instrument, and will demonstrate its delicacy. The apparatus used was not constructed especially for the purpose, but was a part of the University collection.

Induction Currents.—1. The galvanometer was connected with a coil of covered copper wire, No. 11 of the American wire gauge, about ten centimeters long and six in diameter, having a resistance of 0.323 ohm. A small bar magnet, 5 centimeters long and weighing six and a-half grams, gave, when introduced into the coil, a deflection of 40°. On withdrawing the magnet the needle moved 40° in the opposite direction.

2. A small coil, 20 centimeters long and 3.5 in diameter, made of No. 16 wire and having a resistance of 0.371 ohm, through which the current of a Grenet battery, exposing 4 square inches of zinc surface, was passing, was introduced into the centre of a large wire coil, whose resistance was 0.295 ohm, connected with the galvanometer. The deflection produced was 20°. The same deflection was observed on making and breaking contact with the battery, the smaller coil remaining within the larger.

3. A coil of No. 14 copper wire, sixty centimeters in diameter, and containing about 40 turns, the resistance of which was 0.85 ohm, was connected with the galvanometer, and placed on the floor. Raising the south side six inches, caused a deflection of 4°. Placing the coil with its plane vertical, a movement of two centimeters to the right or left, caused a deflection of 3°, and of twenty centimeters, of 10°. A rotation of 90° gave a deflection of 12° and one of 180°, of 24°. These deflections were of course due to currents generated by the earth's magnetism.

4. *Thermo-currents.*—Two pieces of No. 22 wire fifteen centimeters long. were taken, the one of copper, the other of iron wire, and united at one end by silver solder. On connecting the other ends to the galvanometer, the heat of the hand caused a deflection of the needle of 20°.

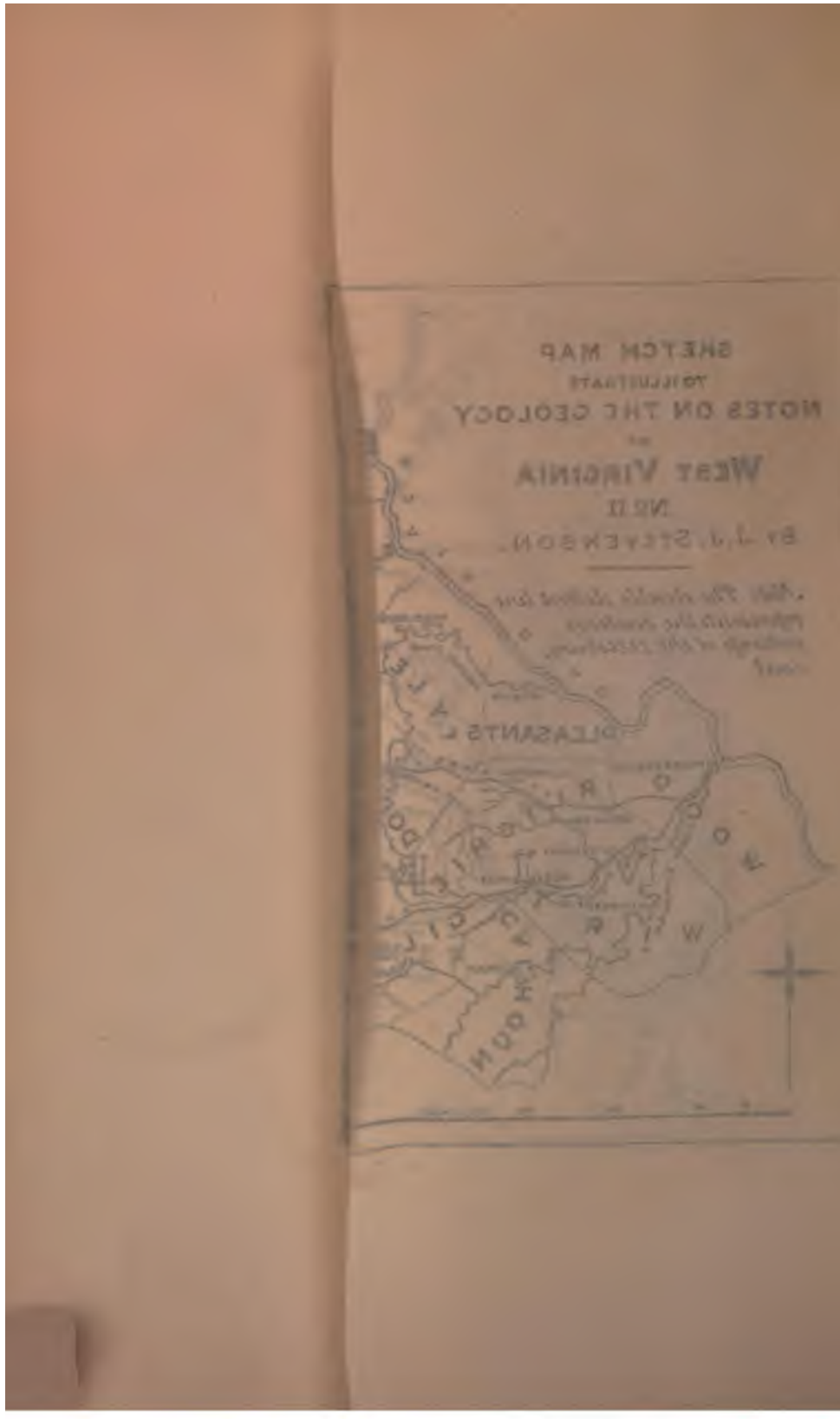
5. A thermo-pile of 25 pairs, each of bismuth and antimony, was connected to the instrument. The heat from the hand placed at five centimeters distance caused a deflection of 3°.

6. Two cubes of boiling water acted differentially on the pile. At the distance of five centimeters, the deflection was 20°; moving one to ten centimeters, the deflection was reduced to 5°.

7. *Voltaic current.*—A drop of water was placed on a zinc plate. While one of the connecting copper wires touched the zinc, the other was made to touch the water. The deflection was 16°.

The claim which is here made for the instrument however, is rather for the general principle of its construction, than for the advantages possessed by the individual galvanometer above described which was constructed at short notice, to meet an emergency. The comparatively small cost for which it may be fitted to the vertical lantern, the readiness with which it may be brought into use, the brilliantly illuminated circle of light which it gives upon the screen, with its graduated circle and needle, the great range of delicacy which may be given to the instrument by varying the coil and needles, so that all experimental requirements may be answered, and finally, the satisfactory character of its performance as a demonstration galvanometer, all combine to justify the record which is here made of it.

Philadelphia, April, 1875.



ERRATA.

The following are the Errata in "List of North American Platypterices &c.," by A. R. Grote, Proceedings No. 93, page 256:

Page 263, line 1: Mr. Lintner states that *Crepera* is the female of Robiniæ.

Page 263, line 21: for "(1793)" read "(1775)."

Page 263, line 30: for "quadrig*a*ttatus" read "quadrig*u*ttatus."

Pl. II.

Fig. 1.

Fig. 2.

PHOTO-ZINCOGRAPH, by F. A. WENDEROTH & CO., 1328 Chestnut Street, Philada.

Pl. III.

Fig. 1.

Fig. 2.

PHOTO-ZINCOGRAPH, by F. A. WENDEROTH & CO., 1088 Chestnut Street, Philada.

Pl. IV.

Fig. 1.

Fig. 2.

Fig. 3.

Fig. 4.

Fig. 5.

Fig. 6.

PHOTO-ZINCOGRAPH, by F. A. WENDEROTH & CO., 1328 Chestnut Street, Phila.

PROCEEDINGS

OF THE

AMERICAN PHILOSOPHICAL SOCIETY,

HELD AT PHILADELPHIA, FOR PROMOTING USEFUL KNOWLEDGE.

VOL. XIV. JUNE TO DECEMBER, 1875. No. 95.

CONTENTS.

PAGE.

On the Geological Relations of the Lignitic Groups of the Rocky Mountains, by John J. Stevenson. (*Read June* 18) 447

On the Remains of Population observed on and near the Eocene Plateau of Northwestern New Mexico, by E. D. Cope. (*Read June* 18) 475

On the Indian Tribes and Languages of Costa Rica, by Wm. M. Gabb. (*Read August* 20) 483

On some further relations of Magnetic, Gravitating, and Luminous Force, by Pliny E. Chase. (*Read June* 18) 607

On the Yearly Rainfall in the United States, by P. E. Chase. (*Read August* 20) 613

On a new occurrence of Tartronic Acid, with some remarks on the Molecular Structure of Glyceric Acid, by Samuel P. Sadtler. (*Read September* 17) 615

On Glacial Action visible along the Blue Mountain, in Pennsylvania, by Charles E. Hall. (*Read September* 17) 620

On the Beginnings of Development, by Pliny E. Chase. (*Read September* 17) 622

Meteorological Observations on the Nile in 1873, by Lieut.-Col. R. S. Williamson. (*Read September* 17) 632

On Glacial Deposits at West Philadelphia, by Charles E. Hall (*with a map*). (*Read November* 5) 633

Stated Meeting, June 18, 1875. Bequest of Mrs. Peale 635

Stated Meeting, July 16, 1875. Dr. Cresson on the Influence of Magnetic Force on the strength of Iron. Prof. Lesley on Mr. Ashburner's Discovery of Coal-beds in the Catskill. Election of Dr. T. M. Drown and Prof. J. L. Campbell 637

Stated Meeting, August 20, 1875 639

Stated Meeting, September 17, 1875 640

Stated Meeting, October 15, 1875. Election of Dr. Stephen Smith, Mr. Wm. Blaxius, Mr. Gideon E. Moore, Mr. Furman Sheppard, Mr. Russell Thayer, Jr., Prof. G. Clark Maxwell, Mr. Charles E. Hall, Mr. John F. Carll, and Mr. Andrew Sherwood 643

THE GEOLOGICAL RELATIONS OF THE LIGNITIC GROUPS.

By John J. Stevenson,

PROFESSOR OF GEOLOGY IN THE UNIVERSITY OF THE CITY OF NEW YORK.

(*Read before the American Philosophical Society, June* 18, 1875.)

The principal lignitic areas of our country are two; one on the Pacific Coast, extending in all from Alaska to Lower California; the other in the Rocky Mountain Region, stretching from the Arctic Ocean to New Mexico. Between the Sierra Nevada and the Rocky Mountains no lignites have been discovered.

Within a few years the controversy respecting the geological relations of these lignites has become very keen, some regarding them as Cretaceous, others as Tertiary. In many instances, the conclusion reached by investigation of the flora is directly contradictory of that reached by study of the fauna. Over a considerable portion of the Rocky Mountain Region the rocks of the Great Lignitic Group are barren of animal remains and only plants are found. Where the fauna is seen the genera and species are usually Cretaceous, and where they are not clearly so they are fresh-water, and therefore of little value either way. The flora is very closely allied in general character to the Tertiary flora of Europe, many species in each being apparently identical.

During my connection with Lieut. Wheeler's Expedition, I passed over a portion of the disputed ground, and so became involved in this controversy. I have thought it necessary to study with care all the material within my reach which seems to bear upon the subject. While this study has shown me that the question at issue is by no means so simple as I supposed it to be, when I rendered my report to Lieut. Wheeler,* yet it has confirmed me in my conclusion there given, that the Great Lignitic Group, or the Fort Union Group of Hayden, is Cretaceous and not Eocene.

It is essential here to determine the value respectively of the various forms of geological evidence, for all have been cited in this discussion, and in some respects they seem to be contradictory.

In every case where applicable, stratigraphy is final. So long as we can trace a rock continuously we have no doubt of its identity. But stratigraphy in this simple form is not often available to any great extent. So variable are the rocks in large areas, owing to the different conditions under which matter may be deposited synchronously at distant localities, that direct comparisons of sections by lithological characters, or even by tracing, becomes impossible. We are compelled, therefore, to resort to palæontology in addition. Our geological column is based upon the succession of the marine invertebrata.

The stratified rocks, with the exception of comparatively insignificant portions, were deposited under the ocean, and of those which contain the remains of terrestrial organisms, by far the greater proportion was formed

* June, 1874.

along the sea-border, exposed to frequent irruptions of sea-water. The lacustrine, or purely fresh-water deposits, are small both in extent and duration, and are confined chiefly to the later portions of geological time. As the sea always covered the greater part of the earth and afforded an easy medium of migration for water-breathing animals, one would expect to find in the rocks of marine origin the most satisfactory record of changes in animal life. This would be a close record of changes in physical conditions, for animals are of a high type of organization, and, therefore, very sensitive to alteration of circumstances. The record is remarkably complete. From the base of the Silurian to the present time the gaps are few and usually of limited extent. In our country there is no group of rocks, excepting one, which does not yield a plentiful supply of invertebrate remains over perhaps the greater part of its area. Even the Triassic, usually so barren in America, is at many localities rich.

So distinct is the succession of invertebrate life, so sharp the breaks at the close of many periods in the world's history, that geologists by common consent have adopted this form of life as the foundation-stone of our system. By stratigraphy the succession of the rocks was determined, but by the succession of invertebrate life the great mass was divided into groups and geological history could be written. Rocks containing a certain fauna were called Silurian, others with a different grouping were termed Cretaceous, and others Miocene. These divisions were made on the basis of the fauna and on no other basis. This should be borne in mind.

The same succession is employed in making the minor divisions. In the Upper Missouri Region a mass of rocks is found, possessing a fauna closely resembling that of a series in Europe, termed Upper Cretaceous. This, all accept as proving that the two series occupy equivalent positions in the geological succession. Closer investigation shows that the Upper Missouri series is made up of five distinct groups, each characterized over an immense area by a peculiar assemblage of invertebrate remains. These groups make the section. If in any portion of the whole Western region we find the fossils of any one of these groups in a mass of rocks, we may legitimately expect to find the others over or under it, as the case may be. It may occur that over large areas a group thus established is perfectly barren of animal remains. This does occur in the Cretaceous groups. The Dakota Group is often barren, and can be identified only by its previously determined stratigraphical relations. The Fort Pierre and Fox Hills Groups, we are told by Dr. Hayden, show extensive zones of barrenness, whereas they are generally prolific. To explain this variation is not always easy, but we cannot do it by any assumption that the prolific portions mark the site of lagoons held by elevation and containing a few relics of a past age. In some instances these "lagoons" would involve us in difficulty, as the fossiliferous layers in different zones occupy different horizons, so that the past age, whose fauna was preserved in the "lagoons," would need to be "past" and "present" alternately for

a long period of time. The lagoon theory is quite ingenious, but unfortunately cannot accommodate itself to the facts.

Some species of invertebrates showed remarkable tenacity of life. Thus *Strophomena rhomboidalis* reaches from the Lower Silurian quite to the base of the Lower Carboniferous. *Atrypa reticularis* existed from near the beginning of the Upper Silurian to near the close of the Devonian. In each group they show marked peculiarities which almost suffice to mark the horizon from which the specimens were obtained. But no palæontologist would be reckless enough to determine a horizon with these shells as his only data. While we find instances of this kind passing upward, we have never found characteristic Carboniferous species in lower formations. But if we should, we must yield to the superior evidence. *Spirifer cameratus* associated with a strongly marked Devonian fauna in rocks occupying the Devonian position, would be a worthless witness. So, if the thing were possible, should we find *Ammonites* at a Silurian horizon, we would reject the testimony in favor of Mesozoic and accept the stronger testimony for Silurian. Even invertebrate life must yield to stratigraphy, if the two contradict.

Vertebrate life is too imperfectly preserved to be ordinarily of much service alone. The succession is not fully given. Yet it may be serviceable. If certain reptilian forms are found constantly associated with a certain invertebrate fauna, as, for example, certain forms in the Cretaceous, we may accept those as evidence where other evidence is wanting, for their horizon has been definitely fixed. This, however, applies only to marine forms. To terrestrial forms, the same objection applies as to plants. In every case, however, the horizon must be fixed for a continent, not for the world, since the conditions affecting such life may have been different in America from what they were in Europe.

Vegetable life shows no such history as to entitle it to much consideration. So patent is this fact that little use has been made of vegetable remains in determining the succession of rocks. Fucoids are worthless except in limited areas, since their organization is so low as to enable them to withstand changes which would be fatal to higher organisms. Land plants are unsatisfactory, because they are preserved in disconnected fragments, and because the areas on which they grew were so widely separated and formed so small a portion of the earth's crust. Let us look at the succession as we find it.

Until a very short time ago the existence of land plants during the Silurian and early Devonian of America was denied, and some told us why no such flora could exist. Two water-worn logs of coniferous wood, found in the Corniferous Limestone, changed our belief, but gave us little information. Respecting the flora of the Middle and Upper Devonian and of the Lower Carboniferous, we have but limited knowledge, and the localities yielding specimens are few indeed. Of the Coal Measure vegetation we know quite well that portion which grew in the swamps, but of the upland flora we have only fragmentary information, in the shape of

stray logs which floated down to the marshes. From the Carboniferous to the Trias, a great change is shown by the fossils, but we have no evidence to prove that this change is a true exposition of the actual change. For aught we can tell to the contrary, a flora closely allied to the one termed Triassic may have existed during the Carboniferous. In the Cretaceous the condition is little better. In the lower portion, leaves of dicotyledonous plants occur in prodigious numbers, but they are not of plants growing where the leaves occur. For the most part they are single leaves, washed in by streams from the land. Between this sandstone and the Lignite Group, there is an interval mostly unrepresented at the East, but at the West occupied by a mass of shales, limestones, and fine-grained sandstones, one thousand to two thousand feet thick, and absolutely barren of leaves everywhere. This was a long period, during which, under the sea, nothing but fine-grained materials were deposited. In the Lignite Group, leaves are numerous, but so far as has fallen under my observation, they are in the same condition as those at the base of the Cretaceous.

Such is the record of plant-life—a record little better than a blank, with here and there a few markings, many of which are too indistinct to be deciphered. In each horizon which yields relics of plants by far the greater portion of the area is barren—even in the Carboniferous age, how small a proportion of the rocks are leaf-bearing in the most favorable localities, while the whole vast area west from the Mississippi has yielded but a beggarly array of specimens. At best, the specimens are fragmentary. The same frond on a fossil fern, when broken up into its pinnules, may yield two or three genera and half a dozen species. When only fragments are found, it is impossible for the palæontologist to resist the temptation to make species. Describing fossil ferns from fragments, is almost as accurate work as making genera and species out of fossil teeth of sharks. In the case of leaves of dicotyledonous plants, the matter is evidently worse. The limit of variation of a species has never been approximately determined among living plants, where one has the whole tree at hand. With only imperfect and separated leaves to study, it would seem almost impossible to determine this matter respecting extinct plants.

Like vertebrate remains, vegetable relics may be made serviceable. The character of the coal flora has been so carefully studied for many years that it is quite well understood. Here, indeed, the matter in many cases is quite simple, for the roof of a coal-bed as exposed in the tunnel of a mine, not infrequently exhibits the material for the reconstruction of an entire plant. Unfortunately, attempts at re-construction are not common, and the investigator is usually satisfied to describe fragments as species, in preference to carefully studying their relation. But the horizon of these plants is now fixed, their general type is well understood, and they can be used as evidence when the animal remains are absent. The day may come when dicotyledonous plants will have been studied to

the same extent. As it is, they are of some local service. The flora of the Dakota Group serves to identify that formation at many localities, east from the Rocky Mountains when the rock is barren of animal remains. The position of this flora has been fixed by means of its position in and below rocks containing the ordinary Cretaceous types of animals.

But why do we call one flora, Cretaceous, or another Triassic, or a third, Tertiary? Simply because it is found in rocks belonging to such a group. Let it not be forgotten that we do not call the group Cretaceous, or Tertiary, because of the flora. Stratigraphy determined the general succession of rocks; animal life determined the division into groups.

The floras of our later geological eras cannot afford a satisfactory basis for generalizations looking to a determination of equivalent horizons in Europe and America. The conditions on the two continents were widely different. This general statement has been practically accepted as true by our palæo-botanists, Dawson, Lesquereux, and Newberry, all of whom have acknowledged that the testimony of plants is inferior to that of invertebrates. This story is a brief one.

In 1858, Mr. Meek and Dr. Hayden submitted to Dr. Newberry a collection of dicotyledonous leaves which they had obtained from the Dakota Group, of Nebraska. Dr. Newberry found great resemblance between these and the Tertiary flora of Europe, but regarded them as of Cretaceous age, being convinced by the stratigraphy and the testimony of invertebrate remains in the overlying rocks. Sketches of some of these were sent to Prof. Heer, who, in a letter to Mr. Lesquereux,* very positively asserted that Newberry erred in his conclusions, and that the plants are all of Tertiary forms. His language is as follows:

"It is true that I have seen only some drawings which were sent to me by Messrs. Hayden and Meek, but they are all Tertiary types. The supposed *Credneria* is very like *Populus leuce*, Ung. of the Lower Miocene, and the *Ettinghausiana* seems hardly rightly determined. Besides, it is a genus badly founded, and as yet has no value. All the other plants mentioned by Dr. Newberry, belong to genera that are represented in the Tertiary and not in the Cretaceous. And it is very improbable that in America the Cretaceous flora had the characteristic plants of the Tertiary, and this would be the case if these plants did belong to the Cretaceous."

To this the editors of the Journal append a note, stating that similar leaves had been collected by Prof. Cooke, from the base of the Cretaceous, as well as by Dr. Newberry, from the same horizon, in New Mexico, so that if the leaves are Tertiary, our Cretaceous is abolished.

Dr. Newberry replied,† stating that he had collected such dicotyledonous leaves from the Lower Cretaceous sandstones at Galisteo Creek, in New Mexico, where the Upper Cretaceous sandstones also are exposed, and at various localities further east to the Canadian river where charac-

* Amer. Journal of Sci., 2d series, Vol. 28, p. 88.

† Amer. Journ. Sci., Vol. 29, p. 299.

teristic Cretaceous 2 and 3 are seen resting upon the sandstones. This statement afforded peculiar gratification to the editor, who takes occasion in another portion of the volume to rebuke Messrs. Marcou and Heer very severely for considering these plants as Miocene. If these plants are Miocene, the editor thinks the roof of our geological house was put on before the foundation was laid. This is a very proper and judicious conclusion.

Mr. Lesquereux's rejoinder* was quite keen, defending Prof. Heer's conclusion and fully endorsing it. So that he, as well as Profs. Marcou and Heer regarded these plants and the including rocks as of Miocene age.

In 1863, Profs. Marcou and Capellini undertook a journey to Nebraska, to effect a final determination of the question. Evidently, the testimony of the plants was of little value in their eyes, for on their return they pronounced the Dakota Group Cretaceous, and not only Cretaceous, but at the base of that series as developed in America. In his work describing the leaves collected by these gentlemen, Prof. Heer confessed the superior value of the faunal evidence, and placed the leaves in the Cretaceous. In 1868, Mr. Lesquereux did the same, describing a number of *Cretaceous* plants from the Dakota Group. In this paper he announces that a remarkable generic affinity exists between the Cretaceous and Tertiary flora of America. In 1874 he published a quarto volume on the Cretaceous flora of the Dakota Group. It is sufficiently evident, then, that Mr. Lesquereux regards his plants as affording by no means positive grounds for generalization respecting equivalence of horizons in Europe and America.

Mr. Lesquereux has claimed that the determination of Miocene character, made by Prof. Heer and endorsed by himself, should not be regarded as in any way affecting the question of testimony, because the material at their disposal was so imperfect. Such a plea is unfortunate, and the excuse is worse than the error, if error it was. If the material was too imperfect to justify a positive conclusion, why was the conclusion so emphatically stated? Either the material was sufficient, or the interpreters are untrustworthy because of rashness. That the material was sufficient is clear, because the general statement of close resemblance to Tertiary forms still holds good. This whole discussion very fairly exposes the value of palæobotany as an aid in the determination of equivalent horizons on disconnected continents.

The plants of the Great Lignite Group are no better. Of these, Mr. Lesquereux has described a great number of species. Of those identified with European forms, the relations, with hardly an exception, are *Miocene*, yet they are placed in the *Eocene*. One very eccentric feature here is, that in some localities the group is Lower, and in others Upper Eocene, while the stratigraphy seems to show that both epochs may belong to the same horizon, and that the difference in the flora is local and synchronous.

*Amer. Journ. Sci., Vol. 29. p. 434.

Why the palæo-botanist should put these plants into the Eocene, rather than into the Miocene, is not known, unless it be done in deference to the stratigraphy.

Other illustrations might be given, such as the occurrence in the American Carboniferous, of types which in Europe are Triassic or Jurassic, but it is hardly necessary. It certainly seems clear to me from the showing of the palæo-botanists themselves, that the plants have nothing to do with the matter; that the fact that certain forms occur at a certain horizon in Europe is no evidence, *pro* or *con*, that their horizon in America is equivalent to that in Europe. The dicotyledonous leaves of the Lignitic Groups, *i. e.*, the Dakota and Fort Union, are locally of service, in that by them we may not infrequently trace the formation on both sides of extensive areas, from which the rock has been eroded, or in localities where the stratigraphical relations are doubtful.

It appears, then, by the common consent of all, that we must determine the European equivalents of our strata by means of animal, not by means of vegetable remains. This being understood, we may look at the facts as we have them.

The Lignitic areas are two, one on the west coast, and the other in the Rocky Mountain Region. The history of these is different, and they require to be taken up separately.

Lignites of the Pacific Coast.

According to Mr. Gabb, the lignites occur at three horizons in this region. At the lowest line are the lignites of Vancouver and the adjacent portions of Washington Territory; higher up he finds the lignites of Monte Diablo, in California. These contain all the workable lignites. But at a still higher horizon there occurs an extensive deposit of lignitic beds, none of which are of economical value. The last group he regards as of Miocene age, but the others he places in the Cretaceous.

The California lignites have been sufficiently discussed by the geologists of that State. I do not know that the reference of these to the Cretaceous has ever been seriously called in question, so that it is unnecessary to speak of them here. The deposits possessing chief interest for us are those of Vancouver. These have been carefully studied by a number of geologists, and the fossil remains, both animal and vegetable, have received close attention from palæontologists of the highest standing. The deposits of Bellingham Bay, Birch Bay, and other localities on the continent, can hardly be regarded as fairly coming within the range of this discussion, as the animal remains have not yet been worked up thoroughly.

According to Richardson, the coal deposit of Vancouver is divided into two distinct fields, one on the east coast, known as the *Nanaimo* Field; the other on the west and northwest coast, named by him the *Comox* Field. Both of these have been examined by him, but his more elaborate work was done in the latter.

The Nanaimo Field was examined by Dr. Hector, in 1859. He succeeded in working out a section of the region, which is practically as follows : *

1. Purple clays		not measured.
2. Conglomerate and sandstone		500 to 600 ft.
3. *Coal*, "Douglas" seam		3 ft. 6 in.
4. Conglomerate		60 ft.
5. *Coal*, "Newcastle" seam		6 ft.
6. Sandstone	about 400 ft.	
7. Conglomerate		
8. Green sandstone		
9. Tufaceous rock		
10. Greenstone conglomerate		
11. Igneous rocks		

No. 8, is richly fossiliferous, containing as determined by Mr. Etheridge, *Trigonia Emoryi*, *Cytherea Leonensis*, *Exogyra* two species, *Arca* three species, *Ostrea* two species.

The sandstone of No. 2, contains a thin coal, accompanied by plant-bearing shales. Yew-like fronds occur in the arenaceous shales associated with the larger coals.

No. 1 is a thick mass of shale somewhat variegated in color and containing great numbers of "nodules or septaria" enclosing fossils. From these nodules there were obtained *Inoceramus Crispii*, (Conrad), *I. Texanus*, *I. Nebrascensis*, *I. unduloplicatus*, *I. confertim-annulatus*, *I. mytiloides*, *Baculites compressus*, *Baculites* two species undt., *Ammonites geniculatus*, *Ammonites* two species undt.

Mr. Brown's† observations at Nanaimo, confirm those of Dr. Hector. In the shales accompanying the coals, he obtained great numbers of leaf impressions, both mono- and di-cotyledonous ; while from the associated sandstones, he procured various species of *Ammonites*, *Baculites*, *Inoceramus*, *Exogyra*, *Ostrea*, *Pecten*, *Arca*, *Trigonia*, *Cytherea*, *Psammobia*, *Tellina*, *Mactra*, *Natica*, *Rostellaria*, etc.

In the northwestern or *Comox* field, he found a grouping of conglomerates, sandstones, fire-clays, and coals similar to that observed in the vicinity of *Nanaimo*. Throughout the series there are fossiliferous beds. Dicotyledonous plants are most frequent among the leaf impressions, while among the animal remains there occur *Ammonites*, *Baculites*, *Pectunculus*, *Plagiostoma*, *Inoceramus*, *Trigonia*, *Hippurites*, *Astarte*, *Natica*, *and Paludina*.

Mr. Richardson‡ examined the Nanaimo field in 1871, and the Comox

*Journal of Geological Society, 1861

†Transactions Edinburgh Geol. Society, Vol. I.

‡Reports Canada Geol. Survey, 1871-2 and 1872-3.

field in 1872. His report for 1871 is not in my possession. In the Comox field the rocks fall naturally into seven well-marked groups as follows :

G. Upper conglomerate	320 ft.
F. Upper shales	776 ft. 6 in.
E. Middle conglomerate	1100 ft.
D. Middle shales	76 ft.
C. Lower conglomerate	900 ft.
B. Lower shales	1000 ft.
A. Productive coal measures	736 ft. 6 in.
Total	4912 ft.

Below these come at once the crystalline rocks, so that the fossiliferous sandstones found below the Nanaimo coals must be absent, or, if present, overlapped by Division A.

Division A, consists of shales, sandstones, and coals, the latter very irregular. The rocks contain no animal remains, though vegetable impressions are abundant. B is made up of brownish-black argillaceous shales with thin layers of gray sandstone and arenaceous shale. The argillaceous portions are rich, both in individuals and species of animal remains. Mr. Richardson obtained *Ammonites*, 7 sp., *Ancyloceras*, 2 sp., *Inoceramus*, 4 sp., undetermined Lamelli-branchiata, 15 sp., and Natica, 1 sp.

Division C is composed of coarse pebbles, held in a brownish-gray sandy matrix, which contains wood and occasional shells. The fossils from this division are rare, as would naturally be expected, but Mr. Richardson obtained one species of *Ammonites* and one of *Arça*. Division D resembles B, but is rather more arenaceous. Thin streaks of coal are common. Lenticular patches of limestone are of frequent occurrence, and yield *Ammonites*, *Baculites*, *Nautilus*, *Ostrea*, *Inoceramus*, *Arca*, *Nucula*, together with numerous undetermined fragments of *Lamelli-branchiata* and *Gasteropoda*.

Division E is an exceedingly coarse conglomerate, and its matrix is a coarse sand. No fossils were observed in the matrix, though some were seen in the included fragments of limestone. Division F resembles D, but is much more arenaceous. Near the top it contains thin streaks of *coal* and many fragments of fossil wood, which show the structure distinctly. For the most part G resembles E, but contains no fragments of limestone. At the base it usually exhibits a mass of gray sandstone, with thin seams of coal and occasional *Belemnites*.

During 1872, Mr. Richardson examined also the deposits in the Queen Charlotte Islands, north from Vancouver. The section shows the following succession, but the groups were not measured :

1. Upper shales and sandstones.
2. Coarse conglomerates.
3. Lower shales with *coal* and iron ore.

Organic remains, both animal and vegetable, occur abundantly throughout Division 3. No. 1 is lighter colored and more arenaceous than 3. Near its base thin layers of argillaceous dolomite occur, and near the top a fossiliferous layer was found.

No doubt those readers to whom these facts are new will feel astonished to learn that any person has ever disputed the Cretaceous age of these coals. The whole trouble has arisen from the finding of some vegetable fragments which have been so far affected by prolonged maceration as to be readily identifiable with almost anything. The interpreters of these impressions are not entirely agreed among themselves.

Mr. Lesquereux* has examined a large collection of plants from Nanaimo and the adjacent portion of Washington Territory. Out of the specimens he made a number of new species, while he recognized a number identical with species previously described in Europe. So closely allied to the flora of the European Miocene are these that Mr. Lesquereux refers both Nanaimo and Bellingham to the Miocene. Somewhat later† he published a letter from Prof. Heer fortifying his position by showing the identity of several of his species with those known in Europe. Both of these palæobotanists agreed in referring Vancouver to the Miocene. The editor of the American Journal of Science felt it necessary to append to this letter an apology for Prof. Heer, in which he stated that the Professor had not had access to the paper by Meek and Hayden on the Vancouver fossils.

The collections made at Nanaimo, Bellingham Bay, and other localities in the vicinity, by Mr. Geo. Gibbs, were submitted to Dr. Newberry,‡ who regarded the Bellingham Bay deposit as most probably Miocene. He had in fact thus announced it in 1856. Some molluscan remains obtained with the leaves, induced Dr. Newberry to regard the Nanaimo coals as Cretaceous. It is evident from his language that nothing in the plants would lead one to suppose that they belong to a Cretaceous horizon, but, on the contrary, that enough was shown by them to cast doubt upon any such conclusion, were satisfactory evidence lacking. His words are as follows:

"The evidence now before us—if the specimens in the collection were obtained in the circumstances reported—shows conclusively that all the plant-bearing strata about Nanaimo are of Cretaceous age; indeed, so far as at present known to us, all the fossils collected at Vancouver's Island are of that formation."

The vegetable remains obtained at Nanaimo, in 1871, by Messrs. Selwyn and Richardson were submitted to Dr. Dawson. Among these were *Taxodium cuneatum*, Newb., *Sequoia Langsdorfii*, Heer, *Sabal*, *Palmacites*, *Populus*, *Quercus*, *Platanus*, *Cinnamomum Heeri*, Lesqx., *Taxites*, *Cupressinoxylon*.

"Dr. Dawson states that the plants led Lesquereux and Heer to refer the beds to the Miocene, but that Newberry has shown that the

*American Journal of Science, 2d series, Vol. 27.

†Ibid., Vol. 23.

‡Boston Journal of Natural History, Vol. 7.

evidence of the associated marine fossils makes them Cretaceous, which is the opinion now generally accepted, the species including *Ammonites*, *Baculites*, etc."*

The 1872 collections of Mr. Richardson were submitted to Dr. Dawson for examination. The results as announced are quite positive, somewhat contrasting in this respect with those already given.† Possibly his conclusions may have been affected by the presence of so great an abundance of animal remains. Be this as it may, his language is open to no charge of obscurity.

"The fossils from the Queen Charlotte Islands, consisting entirely of Pines and Cycads, while decidedly Mesozoic, would indicate a somewhat older stage than the others, say the Jurassic or Lower Cretaceous.

"The fossils from the coal-field of Vancouver, embracing in addition to coniferous trees, both wood and leaves of several species of angiospermous exogens, coincide with those of the Cretaceous of other parts of America, for example of Nebraska.

"The fossils from Hornby Island, in shales believed to overlie those of Vancouver Island, are also Cretaceous, and there is nothing to preclude their belonging to the upper part of that system."

It should be mentioned here that Dr. Dawson refers to the Upper Cretaceous of Europe, the only portion of that system represented in America, east from the Rocky Mountains. The Lower Cretaceous of Europe is probably represented on the Pacific Coast by the Charlotte Island coals and the Shasta Group of the California geologists.

The evidence given by the animal remains is indisputable. The coals at Nanaimo are at the horizon of the Niobrara, or Fort Pierre Group, probably not far from the dividing line. The coals of the Comox field are lower in the system ; while the Queen Charlotte coals may belong to the Lower Cretaceous (of Europe), or to the Jurassic, being on about the same horizon as the Shasta Group of California.

It is certainly very strange, after the publication of facts so convincing as those given years ago by Meek and Newberry, and later by Gabb, Selwyn, Richardson, Dawson, and Billings, that Mr. Lesquereux should still maintain his original statement, as he does in the Seventh Annual Report of the Geological Survey of the Territories. It is the more remarkable because, in a volume published simultaneously with that report, he places his Miocene flora of the Dakota Group at the base of the Cretaceous for no reason except that the Dakota rocks clearly underlie others containing characteristic marine fossils of Cretaceous. This inconsistency may be explained, however, by the fact that he has seen the relations of the Dakota Group in Nebraska, while he has never visited Vancouver.

The Rocky Mountain Region.

In this region there seems to be two horizons of lignitic rocks ; one at the base of the Cretaceous, extending probably from the far north in

*American Journal of Science, 3d series, Vol. 5, page 478.

† Report of Geological Survey of Canada, 1872-3.

British America southward, with more or less irregularity, into New Mexico, along the eastern and southern borders of the mountains, with an occasional lignitic bed in the interior of the region; the other reaching barely beyond our northern line into British America, and extending southward to New Mexico, covering a vast area east from the mountains, as well as within the disturbed region and beyond it at the south in New Mexico.

For a proper understanding of the conditions here, it may be well to give a brief description of the various formations as they are exposed along the east flank of the mountains.

Silurian strata rest upon the metamorphic schists, and above them come the Carboniferous, the Devonian being absent, or not satisfactorily identified. Frequently overlapping and concealing these formations, there is a very persistent mass of red beds, more or less conglomerate, and containing marls and beds of gypsum. These have been referred to the Triassic, principally, however, because of negative evidence. They are succeeded by shales containing limestone, which frequently yields Jurassic fossils. Upon this last rests the Cretaceous, of which five well-marked divisions have been ascertained in the upper Missouri region. These are, ascending,*

No. 1. Dakota Group, sandstones, shales, and lignites.
No. 2. Fort Benton Group, usually argillaceous shales.
No. 3. Niobrara Group, limestones and calcareous shales.
No. 4. Fort Pierre Group, shales with nodules of clay-iron stone.
No. 5. Fox Hills Group, sandstones, more or less calcareous.

In Colorado and New Mexico, especially in the latter territory, it is not always possible to make out the groups accurately, and some of those who have worked in that region are satisfied to use the following classification:

Lower Cretaceous, equivalent to No. 1.
Middle Cretaceous, equivalent to Nos. 2, 3, and 4.
Upper Cretaceous, equivalent to No. 5.

The lower Cretaceous yields animal remains at few localities, and these, in many cases, are of such a character as to render its reference to the Cretaceous a somewhat doubtful one. It contains vast numbers of vegetable impressions, strikingly resembling the Miocene flora of Europe.

The Middle Cretaceous is quite variable in composition, but there are few exposures of the lower portions which will not yield fine collections of animal remains. The ferruginous nodules of the upper part are invariably fossiliferous. It occasionally contains thin beds of lignite, one having been observed at Sage Creek, Wyoming Territory, by Dr. Hayden, and a similar one at Cañon City, Colorado, by myself.

The upper boundary line of No. 5, is very indefinite. Indeed it is the matter in dispute. The rock is sometimes a rusty arenaceous shale but

* This succession was elaborated by Mr. Meek and his co-laborer, Dr. Hayden.

ordinarily a not very compact sandstone, rusty yellow in color and concretionary in structure. In parts it is calcareous, and where it shows such a composition, is very fossiliferous. Dr. Hayden notes the interesting fact respecting the Fort Pierre and this group, that there are zones or belts in which they are almost non-fossiliferous. This feature, observed in the Upper Missouri Region, I found to be quite characteristic of the Upper Cretaceous in Colorado and New Mexico. The group is marked by a rich fauna, largely of Cretaceous forms, but mingled with many types of more recent character.

Above the unquestioned Cretaceous, there comes the great lignite series, termed by Dr. Hayden, the Fort Union Group. This is an immense mass of sandstones, shales, and beds of lignite, having a maximum thickness of not far from four thousand feet. Marine organic remains are commonly found in the lower portions, but over a part of the area, as one ascends in the series, he finds the traces of marine life disappearing, while land and fresh-water shells occur associated with vast numbers of leaves of dicotyledonous plants. The northern and southern portions of this group have never been joined by direct tracing. At the north it underruns the White River Group near Fort Fetterman. From that point southward it is concealed for about three hundred miles, re-appearing from under the same group in Colorado, twenty miles south from Cheyenne. A careful study of Dr. Hayden's reports leaves no room to doubt the correctness of his conclusion that the formation near Fort Fetterman and that south from Cheyenne are the same.

The Lower Lignitic Group.

For convenience in this connection I thus designate the Dakota Group, Cretaceous No. 1. This yields lignites over an enormous area, reaching from the Arctic Ocean into New Mexico, but for the most part the beds are thin and the lignite itself is very impure.

The only detailed reference to this group in *British America*, which I have at hand is that of Dr. Hector.* Sir J. Richardson's "Journal of a Boat Voyage through Prince Rupert's Land," is not within my reach, and his statements in the Appendix to Franklin's Expedition are very unsatisfactory. Dr. Hector's observations were made upon the Saskatchewan River and its tributaries. He found a well-defined series of coal-bearing strata on the North Saskatchewan, or Red Deer River, and on Battle River. On Red Deer River he obtained the following section, descending,

1. Sandstones and dark clays.
2. Banded marlites, clays, and limestones.
3. Shell conglomerate.
4. Clay.
5. Banded clays with clay-iron stone.
6. *Coal*, three feet thick.
7. Clays.
8. Silicified wood and brown coal.
9. Sandy clays.

Total thickness of section, 600 feet.

* Journal of the Geological Society, 1861.

The shell-conglomerate contains vast numbers of *Ostrea cortex*, while the overlying banded clays exhibit *Ostrea cortex*, *O. vellicata* and *Cytherea Texana*, and one of the limestone layers yielded *Ostrea anomiæformis*, *Mytilus*, 2 sp. *Cardium multistriatum*, *Crassatella*, *Venus*, *Rostellaria*, and *Paludina*. In tracing this group from Red Deer to Battle River no change was observed in the section, but at the latter locality, and somewhat higher in the series, a concretionary sandy limestone was found containing *Avicula*, *Cardium*, *Cytherea*, and *Baculites compressus*.*

On the North Saskatchewan the relations of the coals are not shown fully beyond cavil. In that region the formation was traced over a great extent of country and diligently searched for fossils, but without much success. The coals underlie a mass of variegated marly clays, many of them containing comminuted fragments of vegetable matter. These are similar to those of the Red Deer section. In the immediate vicinity of Fort Edmonton, on the North Saskatchewan, there are found fragments of silicified wood, the same as those occurring near the base on Red Deer. In the absence of the higher and fossiliferous strata, Dr. Hector regards the silicified wood and the remarkable lithological resemblance as proving the identity of the two sections as far as compared.

East from the Rocky Mountains, within the United States, the lignite of this group is small in quantity and of very poor quality. A number of localities have been given by Dr. Hayden and others. The lignite is never really workable; and, except at one locality in Wyoming, mentioned by Dr. Hayden, it is not useful for fuel. At one locality, midway between Denver and Colorado Springs, in Colorado, I saw a deserted opening upon a thin bed. It had proved of no value.

In the interior of the Rocky Mountains this group seems to carry lignite very rarely. Prof. Marsh, in 1870, discovered a bed of coal on Brush Creek, a tributary of Green River. Overlying it is a sandstone containing a layer full of *Ostrea congesta*, and further up, another which yielded a crinoid, evidently allied to *Marsupites*. Below the coal, coprolites, cycloidal scales of fish, together with teeth resembling *Megalosaurus* were found. This locality was afterwards visited by Mr. Emmons, who ascertained that the rocks belong to Cretaceous, No. 1.

I regret that the reports of Messrs. Gilbert and Howell to Lieutenant Wheeler are still unpublished. They contain important details respecting the distribution of the lower lignitic series. The report of Dr. Newberry upon the San Juan Expedition has never been printed. It thus happens that, although a large portion of New Mexico has been very closely examined, none of the results are accessible except those obtained by Dr. Newberry on the Ives Expedition and by Dr. J. L. Leconte in 1868.

Dr. Newberry† found this group at many localities in New Mexico, carrying thin beds of lignite. At Camp 92, there is an alternation of

* These fossils were identified by Mr. Etheridge.

† Ives' Expedition. Report on Geology, pp. 81, 85, 87, 89, 94.

coal and shale, twelve feet thick, resting almost directly upon Triassic marls, and underneath a yellowish sandstone filled with dicotyledonous leaves. At Camp 96, and at Oraybe, he found above this bed, green and blue shales two hundred and fifty feet thick. Toward the base this series contains *Ammonites percarinatus*, *Inoceramus Crispii* and *Gryphæa navia*, while toward the top it shows *Pinna* (?) *lingula*, *Gryphæa Pitcheri*, with beds of lignite, above which are impressions of *Platanus*, *Alnus*, *Quercus*, etc., along with *Sphenopteris*. From the Moqui country eastward for about twenty miles, these beds are continuously in sight; but, at length, they under-run a mass of Tertiary rocks, which Dr. Newberry thinks may prove equivalent to the White River Group of the Upper Missouri Region. At Camp 100, beyond the eastern border of this Tertiary basin, a group of lignites and brown sandstones is found between the Triassic and Cretaceous, but it is not persistent. Near Fort Defiance, the Lower Cretaceous Series is seen resting on the Triassic and consists of "green and dove-colored shales, brown and greenish sandstones, brownish-yellow concretionary limestone containing *Gryphæa Pitcheri*, and beds of lignite." The section here is about the same as at Oraybe. At Campbell's Pass, the section is as follows:

1. Cretaceous sandstones, shales, and lignites		700 ft.
2 and 3. Marl Series	Triassic.	750 ft.
4, 5, and 6. Salt Group	Triassic.	520 ft.
7. Carboniferous limestone.		

The shales in No. 1 contain *Gryphæa Pitcheri*.

The same section was traced by Dr. Newberry directly to the Rio Grande, and at Galisteo Creek, not far from Santa Fe, the section is:

1. Cretaceous sandstones and shales with beds of lignites.
2. Red and white marls, all somewhat indurated, with silicified wood.
3. Soft red sandstones of the Salt Group.

Above these are the Santa Fe marls which rest unconformably upon the Cretaceous.

Dr. J. L. Leconte's notes* give few details respecting this region, but they serve to confirm the earlier observations by Dr. Newberry.

In 1869, Dr. Hayden visited Santa Fe and its vicinity. His notes are given in his report for that year. The section obtained by him at Santa Fe is certainly eccentric. On Galisteo Creek, he identifies No. 2 and 4 of the Cretaceous. The remainder of the section is as follows, ascending,

1. *Coal Group*, with abundant impressions of deciduous leaves, resting conformably upon well-marked Cretaceous strata.

2. *The Galisteo Sand Group*, consisting of variegated sands and sandstones, overlying conformably the *Coal Group*, and concealing it on the east and northeast flank of Placière Mountain. This group shows peculiarities here, not seen in the lignite series elsewhere. The color varies

* Notes on the Geology of the Smoky Hill Route.

from light-red to deep brick-red, dull-purplish, deep-yellow, white, brown, drab, etc. The only fossils are silicified trunks of trees.

3. *Santa Fe Marls*, which rests unconformably upon the Galisteo Group, and are of much later date.

Dr. Hayden of course refers this whole section to the Tertiary. Mr. Lesquereux does the same, in consideration of six species of leaves, four of which are peculiar to the locality, and two occur elsewhere, also. But a careful comparison of this section as given by Dr. Hayden, with the details of the geology along Dr. Newberry's route from Santa Fe westward, as given in Ives' report, will, I think, satisfy anybody that Dr. Hayden has by some oversight inverted the order, and that the Galisteo Group *underlies* the Coal Group. The Galisteo Group is unquestionably the Triassic, as abundantly appears from the descriptions of that system in New Mexico, by Newberry and Leconte.

In Utah and New Mexico, Messrs. Gilbert and Howell have found coal beds of much economical value at about the horizon of this group, but their work, being unpublished, is not accessible.

The Upper or Great Lignitic Group.

This is the *Fort Union Group* of Dr. Hayden. Its relations to the Upper Cretaceous are so intimate that the description of the one requires constant reference to the other.

This group, so far as our present knowledge extends, seems to pass but little beyond our northern boundary. For information respecting its character at the north, I have consulted the writings of Messrs. Hayden, Meek, Lesquereux, and Emmons, while for the southern extension in Colorado and New Mexico, I have drawn from the observations of Hayden, Lesquereux, Leconte, Cope, and myself.

Dr. Hector observed some lignites at La Roche Percée, not far north from the United States boundary line, which he regards as the northern extension of the Missouri lignite basin, and therefore places them in the Tertiary, though he thinks they may possibly be Cretaceous. Prof. Hind thinks that they belong to the Fox Hills Group of Meek and Hayden.

Throughout the *Upper Missouri Region*, this Lignite Group is perfectly conformable to the Upper Cretaceous, and the line of separation cannot be determined. During many years of exploration, only one case of unconformability, that between Spring Cañon and Bridger Peak on Laramie Plains, has been found.

On the Yellowstone, below the mouth of Big Horn River, the Upper Cretaceous (5) passes upward into a dark-gray sandstone, containing many Cretaceous species. This, in turn, changes into a coarse-grained friable ferruginous sandstone, containing many concretions. This latter rock yielded a few indistinct bivalves, which were evidently of marine origin. At a locality between Big Horn and Powder Rivers, No. 5 is composed of clay and marls, with layers of concretionary, ferruginous, calcareous sandstone, containing several Cretaceous species. It passes almost imper-

ceptibly into the Lignitic Group above. On Powder River one of the lower sandstones of the latter group has layers hardened by the presence of calcareous matter, so that the rock weathers into architectural forms, the pillars being protected by a cap of the harder rock.

On Gardiner's River the intimate relations of the two groups are well shown. At one locality, where 1200 feet of strata, belonging to them are exposed, it seems impossible to draw any line of division, "this great group of beds, simply alternate beds of sandstone and arenaceous clays, passing down into the dark sombre clays of the Cretaceous." At Cinnabar Mountain, above the mouth of Gardiner's River, "the dark, laminated clays of the Cretaceous, passing up into the Upper Cretaceous, are well shown with perfect continuity, then passing up into a great thickness of the sombre brown sandstones of the Coal Group. There is a great uniformity between the Upper Cretaceous and Tertiary series. We can detect some variations in color and texture, but they are of minor importance and could not easily be described in words."*

On Box Elder Creek, not far from Fort Fetterman, the lignite series consists of rusty sands and sandstones and arenaceous clays, with some seams of lignite. On Deer Creek, twenty-seven miles from the Fort, the black clays of No. 4 are capped by a thin bed of ferruginous arenaceous clays, above which are two beds of sandstone. The lower one of these is concretionary throughout, being filled with sandstone concretions imbedded in an indurated clay, which also shows a tendency to concretionary structure. In the harder portions, a few specimens of *Baculites*, *Inoceramus*, etc., were found. The upper bed has a similar rusty-yellow color, but yields no fossils. Both rocks, but especially the lower one, tend to weather into architectural forms. Near old Fort Casper a yellow ferruginous sandstone, containing *Inoceramus* and huge concretions, is seen resting on black shaly clays which Dr. Hayden assigns to the horizon of Cretaceous, No. 2.

On the North Platte River, from Sage Creek to Medicine Bow, and thence to Bridger's Pass, the sandstones and the associated clays lying at the base of the Lignite Group, are almost continuous. They rest directly upon Cretaceous clays. The sandstones are irregularly concretionary and occasionaly yield an *Inoceramus or Baculites*. Some rusty calcareous beds contain *Ostrea*. Along the Platte, four beds of the sandstone can be distinguished. The first, second, and third, beginning at the base, are in all fifty to eighty feet thick, drab-brown, and quite massive. The fourth is yellowish-gray, full of large rusty-brown concretionary masses, which are laminated, and in reality are arenaceous limestones. Between the beds are thin layers of sandstone and sandy limestones. At Cooper's Creek the rusty arenaceous beds of No. 5 pass up gradually into the coal-bearing layers without any perceptible break, and without any marked change in the sediment. The latter series is from 1500 to 2000 feet thick and consists of rusty-yellow sandstones alternating with greenish-gray

* Hayden. Report for 1871. p. 62.

indurated sands and clays. In the neighborhood of Fort Steele the sandstones, seen at Medicine Bow, are found resting on Cretaceous clays, and passing up into the coal-bearing strata. These contain a characteristic fucoid, which Mr. Lesquereux has designated by the name of *Halymenites major*.

Along the Union Pacific Railroad, from Como to St. Mary's, nearly fifty miles, the lignitic rocks prevail and the heavy sandstone at the base is traceable to Carbon, where a coal overlying it is mined. This is the fucoidal or lignitic sandstone, showing the fucoid just referred to. The overlying rocks contain vast numbers of deciduous leaves. Beyond Rawlings' Springs this series is again seen, overlying Cretaceous clays, and at Separation a coal, probably the same as at Carbon, is worked. At this locality leaves and fresh-water shells are found in the upper portion of the group which appears to be not far from two thousand feet thick.

From Separation to Bitter Creek Station horizontal Tertiary beds prevail, but occasional borings have demonstrated that the coal-strata are not deeply buried. These Tertiary beds are of fresh-water origin and contain *Unio*, *Melania*, and other fresh-water species. They are unconformable to the lignite series and occupy a synclinal trough formed by these rocks.

According to Messrs. Meek and Bannister, there occurs between Bitter Creek Station and Green River an enormous accumulation of coal-bearing rocks, not much less than 4000 feet thick, and underlaid by about 1000 feet of sandstone. The greater portion of the upper series is clearly of brackish-water origin, as it contains layers at various horizons, from which *Ostrea*, *Corbula*, *Melania*, and *Goniobasis* were obtained. Many layers are rich in deciduous leaves, and from one in the upper portion of the series the remains of a saurian were obtained. These were afterwards described by Prof. Cope, under the name of *Agathaumus sylvestris*. Before reaching Green River, these rocks under-run, unconformably, a later series, known as the Green River shales.

Messrs. Meek and Bannister made no examination at Point of Rocks. At this locality Mr. Lesquereux found an anticlinal which exposed the shales of Cretaceous, No. 4, underlying conformably the great fucoidal sandstone. This rock is 185 feet thick, and contains *Halymenites major*, Lesqx. This sandstone has a striking lithological character, which is widely persistent in the Rocky Mountain region. It is a little strange that these Cretaceous rocks do not appear under the Bitter Creek series at Salt Wells, where Meek and Bannister found the great mass of sandstone.

From Green River westward to Bear River the coal rocks are not seen, and the same is true respecting the region between Bear River and Coalville. These areas seem to be utterly isolated. Mr. Emmons finds them surrounded on all sides by the Tertiary beds in such a way as to prevent any junction by stratigraphy with other areas.

At Bear River, the strata have been so distorted that it is not easy to

construct a satisfactory section, but on Sulphur Creek, a tributary of Bear River, Messrs. Meek and Bannister found exposures affording an interesting series of disconnected sections. The following shows the succession, ascending, as far as it seems to have been worked out satisfactorily :

1. Shales and sandstones, not well exposed, about.....	500 ft.
2. Two or three rather heavy beds of yellowish-gray sandstone, with some clays. Near the base, two layers of sandstone occur, containing *Ostrea soleniscus*, *Trapezium micronema*, etc., about.....	100 ft.
3. Greenish and bluish-gray sandy clays and some dark shale.....	100 ft.
4. *Coal*.....	7 ft. 6 in.
5. Massive sandstone, light-colored, with sandy clay at base.....	95 ft.
6. Sandstones, clays, and arenaceous shales.....	275 ft.
7. Not exposed, a horizontal distance of about.....	2100 ft.
8. Light-gray sandstones and clays, including a *Coal bed*, 7 ft. 6 in., sandstone, over coal, containing *Inoceramus problematicus*, *Cardium* and undetermined univalves.....	150 ft.

At Coalville, in Utah, the same gentlemen obtained the following magnificent section. The order is ascending :

1. Sandstones, clays, and arenaceous clays.....	163 ft.
2. Clays and thin sandstones, with *Inoceramus problematicus*, *Cardium subcurtum*, *Lucina*, *Macrodon*, *Modiola multilinigera*, *Corbula*, *Arcopagia*, *Martesia*, *Neritina pisum*, *Turritella*, etc.....	150 ft.
3. Clays and sandstone.....	80 ft.
4. *Coal*.....	13 ft.
5. Yellow-gray sandstones, roof of coal, containing *Inoceramus* and *Ostrea soleniscus?*.....	25 ft.
6. Very dark clay with *Inoceramus problematicus*.....	80-100 ft.
7. Clays and sandstones, not well exposed.....	100 ft.
8. Sandstones, rich in fossils, *Halymenites major*, *Avicula*, *Cardium*, *Trapezium*, *Tellina*, etc.....	100 ft.
9. Clays and sandstones.....	80 ft.
10. Clays and sandstones, with *Ostrea soleniscus*, *Avicula*, *Cardium*, *Tellina*, *Arcopagia*, *Gyrodes*, *Cyprimera*, etc.....	190 ft.
11. Clays, sandstones, and some conglomerate.....	250 ft.
12. Not well exposed, shales and clays.....	600 ft.
13. Shale and sandstone.....	37 ft.
14. *Coal*.....	2½ ft.
15. Clays and some sandstone, with mixed fauna, *Anomia*	

	Inoceramus, Unio, Cardium, Cyrena, etc.	48 ft.
16.	*Coal*	5½ ft.
17.	Concealed	60 ft.
18.	Massive sandstone	220 ft.
19.	Sandstone and sandy clay with *O. soleniscus*	14 ft.
20.	Sandstones and clays, not fully exposed	775 ft.
21.	Gray sandstone, with *Inoceramus, Cardium, Ostrea*, etc.	30 ft.
22.	Sandstones and clays, with fragments of *Ostrea*	191 ft.
23.	Concealed	380 ft.
24.	Conglomerate, more or less coarse	860 ft.
25.	Great Echo Cañon Conglomerate, more than	700 ft.

Mr. Meek is inclined to regard this whole section below No. 25, as not only Cretaceous but as belonging to the Middle Cretaceous, not higher than No. 3. This conclusion appears to be quite improbable. This, it is true, lies very near the western shore-line of the Cretaceous sea, for no rocks belonging to that system have been found west from the Wasatch Mountains at this latitude, which explains sufficiently the coarseness of the sediments toward the base of the section. It certainly seems proper that all above No. 6 should be placed in the Upper Cretaceous, for the fauna approximates the fauna of that horizon. The succession of the rocks below No. 6 fully favors this view.

Mr. Emmons, who has studied this region elaborately, maintains that the Coalville and Bear River areas are but fragments of the great lignite series seen further east, and that they are the western portions of the Bitter Creek Group. That the Coalville section above No. 6, is equivalent to the Bitter Creek Group, and therefore to the Fort Union Group, is rendered very probable when we consider the enormous thickening of the rocks, shown alike by both sections, the general lithological resemblance, and the presence of the fucoid, hitherto unknown below that horizon. Of Mr. Emmons' work nothing has been published, except a brief resumé in Volume III, of Mr. Clarence King's reports. Mr. Lesquereux regards the two groups as practically equivalent.

Returning now to the east face of the mountain, we reach the *Colorado* and *New Mexico* portion of the area, about twenty miles south from Cheyenne. In Colorado and eastern New Mexico, the Lignitic Group shows the following section:

1. Sandstones, yellowish, ferruginous, more or less conglomerate.
2. Sandstones, shales, and *coal-beds*. The sandstones, gray to light-yellow.
3. Sandstone, rusty-red to yellow, brown, and gray, containing thin *coals*, more or less concretionary, and passing downward into a mass of clays and argillaceous sandstones.

In many localities the clays and argillaceous sandstones seem to be almost absent, but where the section is complete, as at Cañon City and

Colorado Springs, they form a perfect and imperceptible transition from the Sandstone No. 3, downward to undisputed Cretaceous. With possibly one exception, the Lignitic and Cretaceous series are everywhere perfectly conformable. Mr. Marvine found distinct unconformability between them in Middle Park near Mt. Bross; but this must be quite local, for Dr. Hayden states respecting Middle Park, in the same vicinity, that the Tertiary rocks are found in great thickness and perfectly conformable to the underlying Cretaceous. At many localities east from the mountains a conglomerate occurs resting unconformably upon the lignitic rocks.

About twenty miles south from Cheyenne, this group is exposed. The Cretaceous passes up imperceptibly into the fucoidal sandstone, which is ninety-five feet thick. At a few feet above the sandstone is a coal-bed, four to six feet thick, roofed by clay, containing an oyster like *O. subtrigonalis*. On Boulder Creek, the same *Ostrea* is found above the coal. Near Golden, the sandstone is separated from the Cretaceous beds by only a few inches of clay, and contains dicotyledonous leaves along with *Halymenites major*. Near Colorado Springs this rock contains a a variable seam of coal, and affords the fucoid and dicotyledonous leaves. Below it are layers of clay and shale, yielding *Baculites* with other Cretaceous forms, and passing downward into Cretaceous dark shales.

In the vicinity of Cañon City, on the Arkansas, the succession is clearly shown. The dark Cretaceous shales gradually merge into a mass of clay and argillaceous sandstones which passes upward imperceptibly into the fucoidal sandstone. In the upper portion of this loose-grained rock there are many impressions of fucoids and, in some of the more compact layers, indefinite impressions of mollusca. In the upper portion of the clay-beds Dr. Hayden found an imperfect *Inoceramus*. From this locality southward, the sandstone is easily followed, standing out like a wall for long distances. Near Trinidad, on the Purgatory River, Mr. Lesquereux found it 200 feet thick, resting on the dark shales of the Middle Cretaceous. On Raton Creek it is 178 feet, resting on the Cretaceous shales, and overlaid by 300 feet of coal-bearing rocks. On Vermejo Creek, the sandstone contains three thin seams of coal. At Cañon City it contains certainly two.

Respecting the relations of the Cretaceous and the Lignitic Group, east from the mountains, Dr. Hayden says, "These black shales pass gradually up into rusty arenaceous clays, which characterize No. 5; and No. 5 passes up into the Lignite Tertiary beds, where they can be seen in contact, without any well-defined line of separation that I could ever discover."*

In its southern extension and near the mountains the fucoidal sandstone is for the most part of a texture unfavorable to the preservation of organic remains and seldom contains any other than very rude specimens of fucoids. Dr. Hayden states, that he has searched it over an area of many miles, but has succeeded in finding no fossils excepting "one

* Reprint of Reports, p. 121.

obscure fragment of a marine bivalve, like the clam, while in the mud-beds and shales below, species of *Inoceramus* are common."* In the Raton Pass, Dr. Leconte found a small *Inoceramus*, badly preserved, as would naturally be expected by any one familiar with the rock. Major Hawn, in his report to Lieut. Ruffner, says that he obtained Cretaceous fossils near Cañon City at only a few feet below the coal. Above this sandstone, in the shales among the coal-beds, there are several layers crowded with an *Ostrea* of undetermined species.

Along the South Platte, about forty miles north from Denver, there occurs a great mass of sandstone which, in my report to Lieut. Wheeler, I have regarded as the great fucoidal sandstone. Mr. Arnold Hague, who explored this region with much care in connection with the Geological Survey of the Fortieth Parallel, maintains that the sandstones belong not at the base, but at the very top of the Lignitic Group. He is doubtless correct. The section, as I followed it, begins at the mouth of St. Vrain's Creek and continues without a break to Evans and Greeley, a distance of about twenty miles. The dip in this direction is quite small, as the road crosses the true dip. My examination here was a hasty one, and I had no opportunity to follow up either St. Vrain's or Thompson's Creek, so as to ascertain what underlies this rock. The whole mass certainly overlies the thin lignites of Platteville. The clays and sandstones seen below the sandstones at the mouth of St. Vrain's bear much resemblance to those below the fucoidal sandstone at Cañon City, and this induced me to regard the section as the same. But a careful comparison and summing up the sections, shows me that the total thickness, several hundred feet, is far too great to permit us to suppose it the fucoidal sandstone, and we must therefore regard it as belonging much higher in the series.†

These sandstones are several hundred feet thick, light-bluish-gray to reddish-brown and yellow, and rest on a mass of clays and shaly sandstones. They are all friable and yield readily to the weather, wearing into immense cavities and breaking down into loose sand. In the reddish ferruginous sandstones, which form the *top* of this group, there are many thin argillo-calcareous layers, which are prodigiously rich in fossils. Some of these are simply masses of the fucoid, *Halymenites major*, Lesqx, while others contain characteristic species of Cretaceous No. 5, such as *Ammonites lobatus*, *Cardium speciosum*, *Nucula cancellata*, *Mactra alta*, *Mactra Warrenana*, *Lunatia Moreauensis*, and undetermined species of *Anchura*. The same species were obtained from this vicinity in 1874, by a party under the direction of Dr. Hayden, to whom I had minutely described the locality.

From the interior of New Mexico we have but little information respecting this group. Much material has been gathered, but it is unpub-

* Reprint of Reports, p. 164.

† I understand that Dr. Newberry proposes to visit Colorado this year. He will examine this vicinity closely.

lished. Prof. Cope* has given a brief statement of its relations in the region northwest from Santa Fe, and lying between the Chama and San Juan Rivers. This region had been visited previously by Dr. Newberry in 1859, and by myself in 1873, but the trails followed merely crossed the region, and only skirted that portion referred to by Prof. Cope. The Tertiary lake mentioned by Prof. Cope is evidently the same with that crossed by Dr. Newberry, when with the Ives Expedition. The Cretaceous here consists of *Lower Cretaceous*, sandstones, *Middle Cretaceous*, mostly dark shales and limestones, *Upper Cretaceous*, sandstones. Throughout the whole series Cretaceous species occur. In the Upper group *Ammonites*, *Baculites*, and other indisputable forms occur in great abundance, associated with *Halymenites major*. The following is Prof. Cope's statement:

"The shore of this lake was formed by rocks of the Cretaceous formation of an age near the No. 3, of Meek and Hayden. In approaching it from the east we traverse the sandstones of Cretaceous No. 1, both horizontal and tilted at various angles, and find No. 2 resting upon it, frequently unconformably, and tilted at higher angles, frequently 45°, sometimes 50°, to the west and southwest, and containing numerous fossils, as *Inoceramus*, etc. The upper sandstones of this formation pass into a brackish or fresh-water formation, which includes a bed of lignite, of sometimes 50 feet in thickness. Above this rests, conformably, where seen, a moderate thickness of rather soft marine rocks, containing numerous shells, *Acephala*, *Gasteropoda*, and *Cephalopoda*, including *Oysters*, *Baculites*, and *Ammonites* resembling *A. placenta* most, with sharks' teeth. Resting unconformably upon these, with a much reduced dip, is a mass of brown and reddish sandstone, some 1500 feet in thickness, inclining perhaps 10° south and southeast. These pass continuously into the superincumbent red and gray marls, alternating with brown and white sandstones of the fossiliferous beds of the Eocene. The observed part of these beds is about 1500 feet in depth."

Having been within not more than fifteen miles from the verge of the Eocene basin, I feel assured that Prof. Cope is inaccurate in his reference of these rocks to Nos. 1, 2, and 3, of the Cretaceous. They are the Lower, Middle, and Upper divisions of the Cretaceous and represent the whole series.

Prof. Cope's mistake was a natural one in his circumstances, as he had devoted no time to the study of the Cretaceous in New Mexico, though he had examined that formation quite closely at the north.

Respecting the geological position of this group there has been great difference of opinion. On one side the statements have been for the most part very positive, while on the other they have been uncertain and more or less compromising. Those who have studied the plants, throw the beds into the Tertiary, while those who have studied the fauna and the stratigraphy regard the greater portion of the mass as Cretaceous though

* Lieut. Wheeler's Report of Progress for 1873. Appendix.

they are generally inclined to admit that the highest portions may be Eocene.

After a careful study of plants collected by Dr. Hayden in the Upper Missouri Region, Dr. Newberry referred the Fort Union Group, as there exhibited, to the Miocene. This conclusion was based upon the close resemblance of this flora to the so-called Miocene flora of Greenland and its intimate relation to the Miocene flora of Europe. Dr. Newberry still holds this opinion respecting the Upper Missouri Region, though he shows some inclination to dispute the assertion, that the southern portion is as recent as the Eocene. The stratigraphical evidence, however, is so strong to prove the identity of the group throughout the Rocky Mountain Region, that all parts of the area must belong to the same horizon. If one part is Miocene the other is Miocene also.

Mr. Lesquereux has published several elaborate and very able papers upon the flora of this group. Though it has close affinity to the Miocene flora of Europe, he does not regard it as Miocene throughout, but divides the series containing it into Upper and Lower Eocene, the former represented at *Carbon*, *Evanston*, and *Sage Creek*, and the latter at *Raton Mountains*, *Golden*, *Black Butte*, *Spring Cañon*, and *Fort Union*. As a whole, he regards this vegetation as Oligocene. Above the Lignitic Group he finds the Miocene at *Green River*, *Elko Station*, *South and Middle Parks*.

Dr. Hayden has long halted between two opinions. He looks upon the Coalville and Bear River sections as Cretaceous beyond doubt, but concerning the rest of the Great Lignite Group he is by no means so decided. Sometimes he speaks of the Lignite Tertiary, at others he seems to regard the group as partly Cretaceous and partly Tertiary, while for the most part in his more recent publications he is disposed to regard the whole as, in great measure, beds of transition. From the beginning his inclination has been to favor the Tertiary hypothesis. Under such circumstances one cannot fail to admire the frankness with which all the facts are given in Dr. Hayden's reports, many of them bearing directly against the deductions previously published by the Doctor himself. Judging from his readiness to receive the truth even at the expense of discarding cherished opinions, there is every reason to hope that before very long Dr. Hayden will be one of the most energetic expounders of the doctrine that the Lignitic Group is Cretaceous.

Mr. Meek refers the Coalville and Bear River areas as well as a portion of the Bitter Creek Series to the Cretaceous but thinks the upper portion of the Bitter Creek section may be Tertiary. He is quite positive that the Black Butte portion of the section is Cretaceous; but this lies far up in the series.

Prof. Cope is very positive respecting the Cretaceous age of the Black Butte section, because *Agathaumus sylvestris* occurs there. Prof. Marsh is equally positive regarding some other localities. Dr. Leconte, Mr. Arnold Hague, and myself have referred the Colorado beds to the Cretaceous.

CONCLUSIONS.

As the Lower Lignitic Group underlies a great mass of strata, containing abundance of Cretaceous species, its geological relations have long been regarded as definitely settled. For precisely the same reason there is no longer room for dispute respecting the Vancouver beds.

In the matter of the Great Lignitic Group the evidence is not so easily obtained as in the other cases, nor, when obtained, is it so absolutely convincing as to stop all discussion. Looking over the facts already given, one finds

First, That the Cretaceous, No. 5, and the Great Lignite Group are everywhere comformable to each other, and that the latter is conformable within itself and unconformable to the fully recognized Tertiaries above it. In an area of many thousands of square miles, which has been closely examined in almost all its parts, only two instances of unconformability between the groups have been recorded, both of which are very local, while one of them is, to say the least, of uncertain existence.

Secondly, That from the beginning of Cretaceous, No. 5, to the close of the Great Lignite Group, there was no change in the general conditions, which would be of more than merely epochal value. The Upper Cretaceous (No. 5), is a rusty yellow sandstone, usually concretionary when compact, which passes upward imperceptibly into the rusty-yellow sandstones at the base of the Lignitic Group, themselves more or less concretionary. Ordinarily the gradation from one to the other is so perfect that they cannot be separated. At few localities indeed is it possible to define any line of separation. In Colorado, the fossils of No. 5 are usually absent from the lower sandstones, so that the Lignitic Group appears to rest directly upon the shales of the Middle Cretaceous. The only fossils characteristic of No. 5, ever obtained from Colorado, were procured from rocks, which are most probably among the very highest strata of the Lignitic series.

The variation in character of the strata above the fucoidal sandstone, giving us shales, sandstones, coal beds, and local limestones, is hardly sufficient to be of even epochal value. The marine conditions remained the same, for the fucoid *Halymenites major* passes through the series, and the land conditions could have undergone but little change, for of the plants, whose leaves occur in the great sandstone, many occur higher up in the group. The sandstones themselves exhibit a very remarkable resemblance to each other. The changes in structure are no greater or more abrupt than those in the Coal Measures. It is quite evident that the relations of the great sandstone (in which I include also that portion termed Cretaceous, No. 5), to the main series of lignites, is precisely the same with that held by the Conglomerate to the Coal Measures. In each case the underlying mass contains thin beds of coal, and is part of the whole series, distinct yet not separate. No one would think of placing the Conglomerate and the Coal Measures in different periods, much less in different ages.

Thirdly, That the conditions observed in the Great Lignitic Group, are but a repetition or continuation of those commonly observed in the Lower Cretaceous and less frequently in the Middle Cretaceous. The sandstones of the Lower Cretaceous, when unaltered, can hardly be distinguished from those of the Lignitic series; coal beds occur at both horizons; while on the Pacific Coast coal beds frequently occur in the Middle Cretaceous.

Fourthly, That the fauna consists for the most part of marine or brackish-water species. At the base of the series, in the great sandstone (including No. 5), the species are all marine; among the coal beds they are usually brackish-water, while at the highest horizon found in Colorado and New Mexico, they are marine. Here and there the fauna is a mixed one, and at times, over no inconsiderable area, it consists solely of fresh-water forms. There would be room for surprise were it otherwise. A shore deposit, such as this must have been, would be exposed to the influence of salt and brackish water alternately. The slow subsidence might be interrupted so as to permit the silting up of portions of the area, where fresh-water ponds of considerable extent might be formed. Such evidently was the case during the formation of the Coal Measures. Dr. Dawson has found a mixed fauna in the South Joggins Coal Field, and Mr. Meek obtained shells, closely allied to *Pupa*, from the upper coals near Wheeling, W. Va. Unfortunately our knowledge respecting the distribution of land and fresh-water forms during geological time is so limited that we cannot trace out the history of genera with any degree of satisfaction. No positive argument, bearing upon age, can be based upon their presence in any group of rocks.

Fifthly, That the fauna, wherever found, is Cretaceous, or of such a character, as to render it neutral testimony, affecting the issue neither in one direction nor the other. Throughout a large portion of the area the fauna is lacking. That barren zones occur in the Upper Cretaceous was observed years ago, by Dr. Hayden, in the Upper Missouri Region. The same is true of it throughout the whole Rocky Mountain Region, north from New Mexico. But we must determine fauna by what we have, not by what we have not. This we do in the Coal Measures, where the barren zones are quite as remarkable as those of the Upper Cretaceous in the Rocky Mountain Region. In the Anthracite area, animal remains are rare; in West Virginia, south from the Baltimore and Ohio Railroad, where the Coal Measures are exposed to a thickness of not far from two thousand feet, there is not a single stratum which is fossiliferous; and in the northern portion of the Great Bituminous Group, where the Coal Measures are nearly three thousand feet thick, there are but two strata, which persistently contain the fauna. Yet west from the Cincinnati axis, over a vast area, animal remains occur profusely at numerous horizons in the series.

A similar condition seems to have existed during the formation of the Lignitic Group. Near the old shore line, animal remains are rare, but as we pass from that line, they become more numerous. It should be re-

membered, that at no great distance from the mountains, this group is no longer within reach, having been removed by erosion, or buried under later deposits. Let us look at the succession of the whole series, Cretaceous and Lignitic, in New Mexico and Colorado:

New Mexico.	*Colorado.*
1. Bright-yellow to red and gray sandstones, more or less conglomerate and concretionary, with lignites, containing many mollusks, and *Halymenites major* throughout.	1. Same as in New Mexico.
2. Shales, limestones, variegated marls, some of the shales sandy.	2. Same as in New Mexice.
3. Bright-yellow to gray sandstones with shales and lignites.	3. Same as in New Mexico.

No. 2 is the Middle Cretaceous representing Nos. 2, 3, and 4 of the Upper Missouri Group, while No. 1 represents the Lignitic Group and Cretaceous No. 5. There is no difficulty in proving the identity of the two sections; it is simply a matter of tracing. In the New Mexico region, Dr. Newberry found at occasional exposures many characteristic Cretaceous species, while in its uppermost layers, Prof. Cope found a rich profusion of specimens.

East from the mountains, at rare localities, Dr. Leconte, in Colorado, and Dr. Hayden, further north, have found Cretaceous species in the lower portions, while in the topmost portions Mr. Arnold Hague and myself have found a grand profusion of species characteristic of Cretaceous No. 5. Far in the interior, Messrs. Meek and Bannister have found the undoubted Cretaceous forms at various horizons in the series.

Sixthly, That there is an utter lack of any positive evidence to show that the series is of later date than the Cretaceous. This statement may seem strange in view of Mr. Lesquereux's very emphatic assertion that the flora proves Tertiary age beyond all doubt.

The reasons given in a previous portion of this paper, are certainly sufficient to show that, in our present stage of knowledge, the testimony of plants can have no bearing upon the discussion. If a witness be shown utterly unworthy of credence in an important case, he certainly cannot be received as trustworthy in a similar and equally important case. *Falsus in uno, falsus in omnibus.* We have seen already that the plants showed the Dakota Group to be Miocene, and the Vancouver Coals to be of the same age. Yet everybody concedes that their testimony was invalid in the former instance, and everybody, excepting Mr. Lesquereux, concedes the same in the latter case.

But Mr. Lesquereux points out that the flora of the Great Lignitic Group is very different from that of the Dakota Group. This is not won-

derful. There would be room for wonder if the upper flora were not very different from the lower one, since the length of time represented by the Middle Cretaceous must have been enormous. Its rocks are limestones, fine shales, and very fine grained sandstones. These certainly were not deposited in haste. What changes in the vegetation were going on during this great period, we have no means of ascertaining, for not a leaf remains to tell the story. We know only that great changes did take place during the interval, since after its close the forms are different from those prevailing before its beginning. But it is very difficult to see how this difference in character is an argument to show that the rocks are Tertiary and not Cretaceous.

But the plants of this group are insufficient witnesses. Their testimony is as bad as that of the Dakota plants. The fucoid, *Halymenites major*, which Mr. Lesquereux does regard as diagnostic of the Tertiary,* is not a Tertiary fossil. It is Cretaceous or nothing, for whenever it is associated with a marine fauna, whether in New Mexico, Colorado, or Utah, that fauna is Cretaceous. Mr. Lesquereux acknowledges this as satisfactory evidence in one part of the series—why not in the other? The land plants are in some instances so eccentric in their range as to be of little service. In the Rocky Mountain region there are found seven species which occur also at Nanaimo. Their distribution in the Rocky Mountain region is as follows, according to Mr. Lesquereux:

Sequoia Langsdorfii, A. Br.	Lower Eocene,	Upper Miocene.
Salisburia polymorpha, Lesqx.,		Upper Miocene.
Sabal Grayana, Lesqx.,	Lower Eocene.	
Populus mutabilis, A. Br.,	Lower Eocene.	
Cinnamomum Heeri, Lesqx.,	Dakota Group.	
Andromeda Grayana, Lesqx.,	Lower Eocene,	Upper Eocene.
Diospyros lancifolia, Lesqx.,		Upper Eocene.

So in the Rocky Mountain region we find the Nanaimo species floating about from the base of the Cretaceous to the top of the Miocene. No doubt the distribution of these species shows that the Nanaimo beds and the Rocky Mountain beds are on the same horizon, and that they are both Lower Eocene as Mr. Lesquereux would have us believe. If they do, the fact must be taken by faith and not by sense.

As already stated, the occurrence of fresh-water shells or of land shells in any portion of the group is not satisfactory evidence, either for or against the Cretaceous or Tertiary age of the deposit.

In view of these facts,

1st. That the series above Cretaceous No. 4, to the top of the Great Lignite Group, is conformable within itself throughout,

2d. That no change of importance occurred in the general conditions during the formation of this series,

* See his remarks on "Coalville" in Hayden's Report for 1872. p. —.

3d. That the Cretaceous from the beginning was a lignite-producing period,

4th. That the fauna, whenever of a character to be compared with known standards is Cretaceous, even to the top of the series,

5th. That the hypothesis that this group or any portion of it is Tertiary is unsupported by definite evidence,

I am compelled to regard the Great Lignitic Group as Cretaceous, simply a renewal of the conditions marking the period of the Dakota Group.

ON THE REMAINS OF POPULATION OBSERVED ON AND NEAR THE EOCENE PLATEAU OF NORTH-WESTERN NEW MEXICO.

By E. D. Cope.

(*Read before the American Philosophical Society, June* 18, 1875.)

While encamped on the Gallinas Creek, at the point where it issues from the Sierra Madre, with the party detailed by Lieut. Wheeler for purposes of geological exploration, I occupied intervals of time in the examination of the traces left by the former inhabitants of this portion of New Mexico.

Had time permitted, the exploration of these remains might have been much extended, but under the circumstances a mere beginning was made. The observations show that the country of the Gallinas, and the Eocene plateau to the west of it, were once occupied by a numerous population. Now, there are no human residents in the region, and it is only traversed by bands of the Apache, Navajoe, and Ute Tribes of Indians. The indications of this ancient population consist of ruined buildings, pottery, flint implements, and human bones. Broken vessels of baked clay are frequently found, and the fragments occur in all kinds of situations throughout the country. They are usually most easily discovered on the slopes of the hills and hog-backs of Cretaceous and Tertiary age, and where abundant, generally lead to a ruined building standing on the elevation alone.

The hog-back ridges which I have described in my geological report, extend in a general north and south direction on the western side of the Sierra Madre, south of Tierra Amarilla. They vary from two to four in number, and stand at distances of from half a mile to three miles from the mountain range. The Gallinas Creek flows between two of them near their southern extremities for perhaps fifteen miles. At one point the hog-backs of Cretaceous Nos. 3 and 4 approach near together, and the creek flows near to the foot of the eastern front or escarpment of No. 3. The rock of this ledge is a hard sandstone, and resists erosion hence its outcrop forms continuous sharp ridges, with distant interruptions, which are termed by the Mexicans the Cuchillas or Cristones. The hog-back of No. 4, being composed of softer material, is worn by erosion into a succession of sub-conical eminences.

My attention was first called to the archæology of the region by observing that the conic hills just mentioned, appeared to be in many instances crowned with stone structures, which on examination proved to be ruined buildings. These are round, or square, with rounded angles and from fifteen to twenty-five feet in diameter, and composed of stones of moderate size, which have been roughly dressed or built without dressing into solid but not very closely fitting masonry. The walls remaining measure from ten feet high downwards. The floor inside is basin-shaped, or like a shallow bird's-nest, and frequently supports a growth of sage-brush (*Artemisia*) of the same size and character as that growing on the plains below, and other shrubs. Sometimes they contain piñon trees (*Pinus cembroides*) of one and two feet in diameter, which is the average and full size to which they grow on the adjacent ridges and plateaus. Within and about them, fragments of pottery abound, while flint implements are less common. As these are similar in all the localities examined, they will be subsequently described. A building more or less exactly agreeing with this description, was found on the summit of every hill of a conical form in the vicinity. Their form is probably due to the shape of the hill, as they were differently built on the level hog-backs. None of the circular buildings were found to be divided, nor were any traces of such buildings observed on lower grounds.

The hog-back of Cretaceous No. 3 is, at the locality in question, only one or two hundred yards distant from the eastern crest of the hills just described, from which it is separated stratigraphically by a bed of lignite. At some points this stratum has been removed by atmospheric erosion, leaving a ravine between the hog-backs. Near the middle of a section of the hog-back of No. 3, a portion of this formation remains, forming a narrow causeway, connecting it with the ridge just behind it. The eastern face is a perpendicular wall of sandstone rock, of about three hundred feet in elevation; the western face is the true surface of the stratum, which here dips about 45° to 55° west by north. The top of the ridge varies in width from four to eleven feet.

In riding past the foot of the precipice, I observed what appeared to be stone walls crowning its summit. Examination of the ridge disclosed the fact that a village forming a single line of thirty-two houses extended along its narrow crest, twenty-two of them being south of the causeway and ten north of it. The most southern in situation is at some distance from the southern extremity of the hog-back. I selected it as a position from which to sketch the country to the south and west; see figures 16 and 17 of the geological report. It is built on the western slope of the rock; a wall of twelve feet in height supporting it on that side, while the narrow ledge forming the summit of the ridge is its back wall. It is square, 3.355 metres on a side, and has a floor leveled with earth and stones. Two stout cedar posts probably once supported the roof; their stumps remain well cracked and weathered. Bushes of sage, similar in size to that of the surrounding plain, are growing within the walls. The

second house is immediately adjoining, and is surrounded by an independent wall, that on the lower side of the ridge being still twelve feet in height. The length of the enclosure is 4.69 metres, and the width 2.68 metres ; full sized scrub-oak and sage-brush are growing in it. The stumps of two cedar posts remain, one five, the other eight inches in diameter. The third house adjoins No. 2, but is surrounded by a distinct wall, except at the back or side next the precipice, where a ledge of rock, completes the enclosure. The latter is 4.02 metres long ; it contains a scrub-oak of three inches diameter, which is an average size for the tree.

Beyond these ruins is an interval of sixty-nine metres, where the summit of the rock is narrow and smooth, and the dip on the west side 55°. The walls of an oval building follow (fig. 1), which enclose a space of 4.69 metres. They are two to two and a-half feet in thickness and stand eight feet high on the western side ; the eastern wall stands on the sheer edge of the precipice. A building adjoins, with the dividing wall common to the preceding house. Its east and west walls stand on parallel ledges of the sandstone strata, whose strike does not exactly coincide with the axis of the hog-back. Diameter of this enclosure 5.37 metres. A space of 15.4 metres follows with precipices on both sides when we reach house No. 6. The eastern wall stands five feet high on the summit of the precipice, from which a stone might be dropped to the ground perhaps three hundred and fifty feet below, only eight feet of the western wall remained at the time of my examination. The enclosure is 6.04 metres long, and not quite so wide, and is divided transversely by a wall which cuts off less than one-third the length of the apartment. In one of the opposite corners of the larger room is the stump of a cedar post five inches in diameter. This house can only be reached by climbing over narrow ledges and steep faces of rock. House No. 7, follows an interval of 42.30 metres. Its foundation wall encloses an irregular square space 4.70 metres long and 3.69 metres wide ; it is eleven feet high on the western side, and very regularly built, and well preserved ; on the east side it is eight feet high, and is interrupted by a doorway of regular form. From this a narrow fissure offers a precarious hold for descent for a considerable distance down the face of the precipice, but whether passable to the bottom I could not ascertain.

The crest of the ridge is without houses for 52.34 metres further ; then a building follows whose enclosed space is an irregular circle of 4.70 metres diameter. A transverse summit-ledge forms its southern wall, but the remaining portion is remarkably massive, measuring three feet in thickness. Its western wall is twelve feet high, and contains many huge stones, which four or five men could not lift unaided by machinery.

Several scrub-oaks, of three inches in diameter grow in this chamber, and stumps of the cedar posts that supported the roof remain. Here follows a row of ten similar ruined houses, measuring from 3.35 to 6.24 metres in length. Of these, No. 13 is remarkable for containing a scrub-oak of thirteen inches in diameter, the largest that I have

seen in the country, and the species is an abundant one. In No. 14, the remaining part of the western wall is fifteen feet in height. There was a good deal of pottery lying on the western slope of the rock, but of flint implements and chips, I found but few. All of these ruins contain full-grown sage-bushes. No. 18 is the largest ruin; the length of its enclosure is 8.62 metres, and the width 6.71 metres; its west wall is six feet high; the floor is overgrown with sage of the largest size. This building stood 51 metres from No. 17; 12.80 metres northward, the ridge descends slightly to the level of the causeway already mentioned. Here are five more ruined buildings of the same average size as the others, interrupted by but one short interval.

From this depression, that part of the hog-back which is north of the causeway rises abruptly in a perpendicular face. It is composed principally of two layers of the sandstone dipping at 45°W. which are separated by a deep cavity from a point fifteen feet from the base upwards. This niche has been appropriated for a habitation, for it is walled across to a height of six feet from its base. The foot of the wall is quite inaccessible, but by climbing round the eastern face of the precipice, a ledge is found at the base of the projecting stratum which forms the east wall of the enclosure. This was scaled by means of a staircase of stones, a number of which were in position at the time of my visit. The remaining portion of the hog-back is elevated and smooth, and the foundation stones only of several houses remain. One of these contains two stout posts of which four feet remain above ground; the last is near the end of the ridge, and is bounded by a wall of ten feet in height which forms its western side.

The walls of these houses are built with a mortar of mud, mixed in many cases at least with ashes, judging from the abundant specks of charcoal which it contains. It is not of good quality, and has weathered much from between the stones. I could not discover any indication of burning of the houses by fire, either on the stones or the cedar posts. The latter doubtless lost, by weathering, such indications had they existed, and the combustion of the entire contents of such small edifices could have affected their stone walls but little. I found no remains of bones of animals or men about them.

This town I called Cristone. The same hog-back recommences a little more than a mile to the north, rising to a greater elevation, say six or seven hundred feet above the valley. The east side is perpendicular, while the dip of the west side is 60°, and sometimes even a higher angle. On this almost inaccessible crest, I could see from the valley the walls of ruined stone buildings such as I have described, but unfortunately my limited time prevented me from making a detailed examination of them. In the opposite direction, I observed a similar ruin on an outlying hill adjacent to the southern portion of the southern hog-back. This one is of larger size than any of the others; but I was unable to visit it.

The position of these buildings is susceptible of the same explanation

as that of the still inhabited Moquis villages of Arizona, so interestingly described by Lieutenant Ives in his report on his survey of the Rio Colorado of the West, and of the route from its cañon to Sante Fé. They were doubtless perched on these high eminences for purposes of defense, and they were conveniently located near a perennial stream, which permitted them to carry on a system of agriculture, no doubt similar to that now practiced by the Moquis. The inhabitants of Cristone felt, however, one disadvantage not known to the Moquis; they were, so far as present indications go, without water on their elevated rocks, but were dependent for their supply on the Gallinas Creek. I found no indications of cisterns which should furnish such supply in time of siege, although they doubtless could depend for a considerable length of time on rain-water which they caught and preserved in the many vessels of pottery whose fragments are now so numerous about the ruins.

At this point the bluffs of the Eocene bad-lands are from nine to ten miles from the Gallinas Creek. Here also the slopes are in places covered with broken pottery, and on the summit of some of the less elevated buttes, circular walls indicate the former existence of buildings similar to those crowning the conical hills along the creek. The latter contains the nearest water to these ruins. In other localities ruined stone buildings occupy the flat summits of mesa hills of the bad-lands, often in very elevated and well-defended positions. It was a common case that the erosion of the faces of these bluffs had undermined the foundation of the houses, so that their wall stones, with the posts were mingled with the pottery on the talus below. At one point, foundation walls stand on an isthmus connecting a butte with the mesa, of which a width of twenty feet remains, but which is furrowed with water channels. Here Eocene fossils and crockery, including a narrow-necked jug, were confusedly mixed together. At another point the narrow summit of a butte of nearly two hundred feet elevation is covered with remnants of stone buildings which extend for a length of two hundred yards. The greater part of them had been undermined, and the stones were lying in quantities on talus at the time of my visit. At one end of the line, the bases of two rectangular walls, perhaps of towers, appeared to have been placed as supports to the terrace. Very dry cedar posts occur among the ruins, and three such, standing upright on the summit of the butte, mark a spot as yet unaffected by the disintegration of the cliff. In another portion of the ruins, a row of large earthenware pots was found buried in the earth; the slow moving change of level of the marl had already fractured them. At another locality I took from a confused mass of ruins, the temporal bone of an adult person, the ilium of a child, ribs and other bones. At a remote portion of the ruins on a remaining ledge, I found a square enclosure formed of stones set on edge, three stones forming each half of the enclosure. I excavated this for the depth of a foot, without finding any indication of its use. In some of these localities, I found chips, arrowheads, and thin knives of chalcedony, with similar implements of obsi-

dian. The obsidian knives are similar to those which I have seen as commonly found in Mexico.

At the head of the Cañoncita das Heguas there are numerous low hills of the Eocene marl, covered with piñon forests of adult trees. On a low slope of one of these, I found the burial place of one of the inhabitants, as indicated by his bones, and trinkets doubtless buried with him. His tibia was a marked example of the platycnemic type. Close to them were some good quartz crystals, of course intruded in such a formation, a piece of *chalchuitl*, an apparently transported scaphite, some implements of obsidian, flint, etc., and a single perfect lower molar of a large mammal of the genus *Bathmodon*, attached to a piece of the jaw, which looked as though the ancient proprietor had not been ignorant of the peculiar products of the neighboring bluffs.

In traversing the high and dry Eocene plateau west of the bad-land bluffs, I noticed the occurrence of crockery on the denuded hills for a distance of many miles. Some of these localities are fifteen and twenty miles from the edge of the plateau, and at least twenty-five miles from the Gallinas Creek, the nearest permanent water. In some of these localities the summits of the hills had been eroded to a narrow keel, destroying the foundations of the former buildings.

In no locality did I observe inscriptions on the rocks or other objects, which were probably the work of the builders of these stone towers; but I give a copy of figures which I found on the side of a ravine near to Abiquiu, on the river Chama. They are cut in Jurassic sandstone of medium hardness, and are quite worn, and overgrown with the small lichen which is abundant on the face of the rock. I know nothing respecting their origin.

It is evident that the region of the Gallinas was once as thickly inhabited as are now the more densely populated portions of the Eastern States. The number of buildings in a square mile of that region, is equal to, if not greater than the number now existing in the more densely populated rural districts of Pennsylvania and New Jersey. Whether this is the case to the south and west, I do not know, as I was unable to devote the necessary time to the examination. I found, however, that without investigation, it is very easy to pass the ruins by unnoticed, since their elevated position, ruinous condition, and concealment by vegetation, render them almost invisible to the passing traveler. In general, I may say that the number of ruins I found, was in direct proportion to the attention I gave the matter; where I looked for them I invariably found them in suitable situations.

Perhaps the most remarkable fact in connection with these ruins is the remoteness of a large proportion of them from water. They occur everywhere in the bad-lands to a distance of twenty-five miles from any terrestrial source of supply. The climatic character of the country then has either undergone material change, or the mode of securing and preserving a supply of water employed by these people, differed from any known to us at the present time. I found no traces of cisterns, and the

only water holders observed were the earthenware pots buried in the ground, which did not exceed eighteen inches in diameter. There is, however, no doubt that these people manufactured great numbers of these narrow-necked globular vessels, whose principal use must have been the holding of fluids, and chiefly of water. Nevertheless, it is scarcely conceivable that the inhabitants of the houses now so remote from water, could have subsisted under the present conditions. Professor Newberry (Ives' Report) is of the opinion that a diminution in the amount of rain-fall over this region has taken place at no very remote period in the past, and cites the death of forests of pine trees which still stand, as probably due to increasing drought. It is of course evident, that erosive agencies were once much more active in these regions than at present, as the numerous and vast cañons testify, but that any change sufficient to affect this process should have occurred in the human period, seems highly improbable. In other words, the process of cutting cañons of such depth in rocks of such hardness is so slow, that its early stages which were associated with a different distribution of surface water supply, must have far antedated the human period.

Nevertheless, if we yield to the supposition that during the period of residence of the ancient inhabitants the water supply from rains was greater than now, what evidence do we possess which bears on the age of that period? There is no difference between the vegetation found growing in these buildings, and that of the surrounding hills and valleys; the pines and sage-brush are of the same size, and to all appearances of the same age. I should suppose them to be contemporary in every respect. In the next place, the bad-lands have undergone a definite amount of atmospheric erosion since the occupancy of the houses which stand on their summits. The rate of this erosion under present atmospheric influences is undoubtedly very slow. The only means which suggested itself as available at the time, was the calculation of the age of pine trees which grow near the base of the bluffs. These have, of course, attained their present size since the removal of the front of the stratum from the position which the trees now occupy, so that the age of the latter represents at least the time required for the erosion to have removed the bluff to its present position. But how much time elapsed between the uncovering of the position now occupied by the tree and its germination, there is, of course, no means of ascertaining. My assistant, an educated and exact man, counted the rings in a cut he made into the side of a piñon (*Pinus cembroides*) which stood at a distance of forty feet from a bluff, not far from a locality of ruins. In a quarter of an inch of solid wood he found sixteen concentric layers, or sixty-four to an inch. The tree was probably twenty inches in diameter, which gives six hundred and forty annual growths. The piñon is a small species, hence the closeness of the rings in an old tree.

At present it is only possible to speculate on the history of the builders of these houses, and the date of their extinction. The tribes of Indians at present inhabiting the region at irregular intervals, can give no account

of them. But it is not necessary to suppose that the ruin of this population occurred at a very remote past. On the Rio Chaco, not more than thirty miles from the Alto dos Utahs, are the ruins of the seven cities of Cibolla, the largest of which is called Hungo Pavie. These have been described by General Simpson,* who shows that each of the towns consisted of a huge communal house, which could have accommodated from 1500 to 3000 persons. Their character appears to have been similar to that of the existing Moqui villages. The "cities of Cibolla" were visited by the marauding expedition of Coronado, in 1540, which captured them to add to the vice-royalty of Mexico. In his letter to Mendoza, the viceroy, Coronado, states that the inhabitants on the fourth day after the capture "set in order all their goods and substance, their women and children, and fled to the hills, leaving their town as it were abandoned, wherein remained very few of them." There can be no doubt that the Eocene plateau and hog-backs of the Gallinas offer hills of the greatest elevation in the entire region, and it is highly probable if the account quoted be correct, that some at least of the exiled Cibollians found a refuge in this region, and may have been the builders of Cristone. This would place the age of the ruins described, at three hundred and thirty-five years. Of course, it is possible that they represent villages contemporary with and tributary to the seven cities.

The inhabitants of the rock-houses of the Gallinas, necessarily abandoned the communal type of building generally employed by their race, and appear only to have considered the capacities of their dwellings for defense. Yet the perils of life in Cristone, due to the location alone, must have been considerable. Infant sports must have been restricted to within doors, and cool heads were requisite in adults to avoid the fatal consequences of a slip or fall. Intoxication must have been rare in Cristone. There is no trace of metal in any of the ruins of the Gallinas, and it is evident that the inhabitants were acquainted with the use of stone implements only, as was the case with the builders of Central America. I have already alluded to their pottery. It is usually of a bluish-ash color, but is occasionally black, brown, and more rarely red. It is never glazed, but the more common kind is nicely smoothed so as to reflect a little light. This pottery is ornamented with figures in black paint, which are in lines decussating or at right angles, or enclosing triangular or square spaces; sometimes colored and uncolored angular areas form a checker-board pattern. The coarser kinds exhibit sculpture of the clay instead of painting. The surface is thrown into lines of alternating projections and pits, by the use of an obtuse stick, or the finger nail; or it is thrown into imbricating layers by cutting obliquely with a sharp flint knife. Thus the patterns of the ornamentation were varied according to the taste of the manufacturer, although the facilities at their disposal were few.

With these observations, I close this sketch of a glimpse at one locality of the earliest civilization known on the American continent.

* Report of St. Jas. H. Simpson, of an expedition in the Navajoe Country in 1849. Ex. Doc. 1st Sess. 31st Congress.

ON THE INDIAN TRIBES AND LANGUAGES OF COSTA RICA.

BY WM. M. GABB.

(*Read before the American Philosophical Society, August* 20, 1875.)

CHAPTER I.

GENERAL ETHNOLOGICAL NOTES.

The Indians of Costa Rica, with the hardly probable exception of the Guatusos, all belong to one closely allied family. I only make this possible exception in deference to the almost absolute ignorance which yet exists in regard to this isolated tribe.

Before entering on the consideration of the better known peoples of the southern part of the Republic, it may be as well to make a brief summary of what is known of the Guatusos up to the present time. They occupy a part of the broad plains north and east of the high volcanic chain of North-Western Costa Rica, and south of the great lake of Nicaragua, especially about the head waters of the Rio Frio. I have fortunately fallen in with various persons who have entered their country, and who have had an opportunity of seeing the people and their mode of life. The stories of some are so evidently exaggerated that I shall suppress them; but by carefully sifting the evidence and giving a due preponderance to the testimony of those whom I consider most reliable, I have arrived at the following results.

Thomas Belt, the author of "The Naturalist in Nicaragua," says he has seen of them, five children and one large boy, "and they all had the common Indian features and hair; though it struck me that they appeared rather more intelligent than the generality of Indians." He also says that "one little child that Dr. Seeman and I saw in San Carlos in

1870, had a few brownish hairs among the great mass of black ones; but this character may be found among many of the indigenes, and may result from a very slight admixture of foreign blood." All the persons with whom I have conversed assert that the name Guatuso, as applied to the tribe, is given on account of a reddish or brown tint of their hair, resembling the little animal of that name (the *Agouti*). This is also denied by Mr. Belt, who says that the names of animals are often applied to Indian tribes by their neighbors, to distinguish them. Allowing full weight to this opinion, supported by analogy as it is in North America, (*e. g. Snakes,*) I do not think it fully warranted in this case.

Of half a dozen persons with whom I have conversed; people who have been on the upper Rio Frio, all, with one exception, distinctly assert that they have seen people of light color and with comparatively light hair among them. One person went so far as to assert, that in a fracas in which he nearly lost his life, his most valiant and dangerous opponent was a young woman, a mere girl, "as white as an Englishwoman," (tan rubia como una Inglesa). Another, who had a more peaceful opportunity of seeing a party of two or three women, himself unseen, used the same words in describing one of them. I believe, however, that these were exaggerations. Still another person told me that they were of all shades "from a rather light Indian color, to nearly white, the same as ourselves" (referring to the varying shades in the mixed blood of the Costa Rican peasantry). However, in an interesting conversation with Don Tomas Guardia, President of Costa Rica, I learned that when, some years ago, he headed a party passing through their country for military purposes, they encountered one or more bodies of these people and had some skirmishes with them. He says they are ordinarily of the color of other Indians, although rare exceptions exist, of individuals markedly lighter than the others, and really possessing a comparatively white skin and brownish or reddish hair. This is in keeping with the statements made to me by others whom I consider reliable, and must, I think, in deference to the authors be taken as final.

The origin of light complexions among an isolated tribe of Indians has, of course, been the source of much speculation, but General Guardia, and Don Rafael Acosta, an intelligent gentleman of San Ramon, not far from the borders of the Guatuso country, both suggested to me, independently, the same theory. They claim that when, a couple of centuries ago, the town of Esparza was sacked by the English freebooters, many of the inhabitants took refuge in the mountains, and were never afterwards heard of. These refugees were many of them pure whites, men and women. Now from Esparza, it is only about three or four days' journey to the borders of the Guatuso country, and it does not seem improbable that some of these poor wretches may have found their way there. If this is really the case, the admixture of blood, and consequent lightening of color is satisfactorily accounted for.

In consequence of almost uniform bad treatment, robbery and massacre

included, to which these people have been subjected by the rubber hunters, who enter their country from Nicaragua, and their not possessing fire-arms to repel the aggressors, they have become so timid that they fly on the first approach of strangers. The few who have been captured are either young children, or persons taken by surprise. I have been unable to learn of any in Costa Rica, although a boy, now dead, lived for a while in Alajuela. A few are said to have been taken to San Juan del Norte, (Greytown,) and to Grenada, Nicaragua. The Alajuela boy, although he learned the meaning of some Spanish words, so as to know what was meant, when spoken to, was represented as sullen. When asked the names in his language of things that he was familiar with, like plantain, banana, &c., he always remained silent, and neither coaxing nor threats could extort a word.

The people are invariably represented as of short stature, broad, and of enormous strength. They live in neighborhoods; they cannot be called villages, the houses being scattered over an extensive area and at distances of from one to several hundred yards apart. The houses are low, consisting of a roof, pitching both ways from a ridge pole, and resting on very short but very thick posts. This is thatched with palm leaf and is entirely open at the ends and sides, under the eaves. Their tools are stone axes set in wooden handles, good steel machetes (all agree that they have seen these, but where do they get them?) and planting sticks similar to those used by the Bri-bris. With these tools they cultivate great quantities of plantains, bananas, yuca, coco, (*Colocasia esculentum*,) besides possessing large plantations of the *pehi balla* palm and of cacao. Of the furniture in their houses, I was told of cord hammocks and net bags, similar to those of Bri-bri, and of blocks of light wood for seats. They seem to sleep on the ground floor of their houses, simply spreading down a layer of plantain leaves. Their bows and arrows are described as similar to what I have seen elsewhere, except that the arrows are not supplied with any harder points than those furnished by the pehi balla wood. The dress is described as identical with the old styles in Talamanca; mastate breech cloths for the men, and the same material, in the shape of short petticoats for the women.

The country of the Rio Frio is said to consist of broad fertile plains, unsurpassed in beauty and fertility by any lands in the Republic. The Rio Frio itself is large and is navigated by the large canoes of the *huleros*, or rubber hunters, to a point within three days' walk of Las Cruces on the Pacific side. But the poor inoffensive people who inhabit this region are now so intimidated by the "Christians" who have visited them, that they can only be approached by a foreigner by stealth. If they can escape they do so, but if driven to bay, or think they can overpower the strangers, they greet them with a flight of arrows. They are especially afraid of firearms, and a pistol shot is sufficient to depopulate a settlement.

I believe the above short statement contains the most reliable informa-

tion ever yet accumulated with reference to the Guatusos. I have carefully rejected many wonderful stories told me by persons claiming to tell what they saw, and have only availed myself of the accounts of those who seemed to exaggerate least, or whose position forbade me to doubt their assertions.

The tribes of Southern and South-eastern Costa Rica are better known. The Terrabas, living on the Pacific slope, and their neighbors, the Borucas or, as they call themselves, Bruncas, live under complete subjection to the laws of Costa Rica, and the rule of a missionary priest. They may be strictly called civilized. But those on the Atlantic slope have had a powerful ally in the forces of nature, in resisting the civilizing efforts of the Spanish invaders. The heavy rains of the Atlantic seaboard produce a luxuriance of vegetation that may well nigh be called unconquerable. Broad swamps, dank and reeking with malaria threaten the European with bilious fever, fatal to energy if not to life. Three centuries ago Columbus sailed along the coast from the Bahia del Almirante, and in his usual florid style called this the Rich Coast, and yet it has never yielded to the conqueror or paid him tribute. Two centuries ago a little colony was planted far back in the mountains and one or two outlying missionary posts were scattered among the then powerful tribes. But a just retribution fell on San José de Cabecar. The hardy mountaineers did not submit to the oppressors' yoke like the gentle and hapless victims of Cuba and Santo Domingo. Even now the traditions are well preserved among them, and I have listened to more than one recital of outrages which I dare not believe to be exaggerated. Father Las Casas tells of even worse oppressions. In 1709 the people rose and massacred all who fell into their power. A pitiful remnant escaped from the colony, to wander for weeks in the woods and finally a handful reached Cartago. The Viceroy of Guatemala, in retaliation sent forces by way of the forest trails from Cartago and others across the mountains by way of Terraba. They surrounded, killed, and captured all the Indians they could, and carried their prisoners to Cartago. Some of these were divided among the settlers as servants, and have left a strong tinge on the cheeks of many a would-be high-toned Costa Rican. The remainder were settled in the villages of Tucuriqui and Orosi, where, though partly civilized, they still retain their original language, badly corrupted with Spanish. Since this disastrous ending to the colony, both parties have kept up a wholesome dread of each other and no further efforts have ever been made to found a colony on the Atlantic side of the country. At the same time, the Indians not only dread, but hate the Spaniards and even a trace of Spanish blood, or fluency in the language on the part of a dark-skinned or dark-haired person is a warrant for suspicion. It is not a hatred of the white race. Englishmen, Americans, and Germans are invariably respected and treated well, by the same people who are either insolent to the Spaniard or treat him at best with restraint.

On the Atlantic slope, there are three tribes intimately allied socially,

politically, and religiously, but differing markedly in language. The Cabecars occupy the country from the frontiers of civilization to the western side of the Coen branch of the Tiliri or Sicsola River. Adjoining them, the Bri-bris occupy the east side of the Coen, all the regions of the Lari, Uren, and Zhorquin and the valley lying around the mouths of these streams. The Tiribris, now reduced to barely a hundred souls, live in two villages on the Tilorio or Changinola River. It is said that on the head waters of the Changina, a large fork of this latter stream, there are yet a few individuals of the Changina tribe, but the other Indians report them as implacably hostile and their very existence is only known by vague reports of their savage neighbors. The Shelaba tribe, formerly living on the lower part of the same river is now entirely extinct. A few half-breeds are all who perpetuate the blood, and their language is utterly lost. Still further down the coast, beyond the Costa Rican boundaries is another allied tribe, partly civilized, in so far as that they trade and work a little and drink a great deal of bad rum, spending most of their earnings on that bane of the race. They are called by foreigners Valientes. Crossing over to the Pacific slope, the Terrabas are tribally identical with the Tiribis. The tradition still exists in a vague form, that they are emigrants from the Atlantic side; but when or why the emigration took place, is forgotten. The home of the tribe is in a very narrow, rough cañon, traversed by a river that might better be called a torrent, a country strongly contrasted with the fertile plains and broad savannas of Terraba, and it is not improbable that under the press of a crowded population several migrations took place. They still tell how, twenty or thirty years ago, a priest came over from Terraba, baptized all who would submit to the rite, and by glowing stories of the abundance of meat and other inducements that he shrewdly imagined would tempt them, carried off over a dozen of their best men, who never returned. A glance at the vocabulary will show how little separated are these two branches of the tribe in language. The Borucas or Bruncas, who occupy a little village, not far from the headquarters of the Terrabas, are apparently the older occupants of the soil; perhaps crowded into a corner by the invaders.

Other tribal names are mentioned by various authors, such as Biceitas, &c. The name Biceita is not known in the country, and, although used to the present day outside of the Indian country, is unknown to them, or at best, is supposed to be a Spanish word. The district of that name is probably the western part of Bri-bri, the most eastern point to which the slave-hunting expeditions from San José Cabecar penetrated. The Blancos are properly the Bri-bri tribe, but this word is rather loosely used, and is often applied alike to the Cabecars and Tiribis.

But little can be gathered of the history of these people. What happened in the times of their grandfathers is already ancient history and partly forgotten. All recollection of the first arrival of the Spaniards is now lost. They have no traditions of the use of stone implements before the introduction of metal. When asked what they did for axes before the traders

came among them, I could get no more satisfactory answer than that they went to Cartago to buy them. I have been told a vague story, however, that long ago there were two bands living in the country now occupied by the Bri-bris. Those living in the valley, around the junction of the branches of the Tiliri were more powerful than the mountaineers, and forced the latter to pay tribute when they descended to hunt, or cut the material for their bark-cloth clothing. But gradually the lowlanders died out; the highlanders, becoming the more powerful, rebelled against these impositions, and eventually emigrated in such numbers to the country of the former, that the distinction became lost by an amalgamation of the two parties. Even now the Bri-bris, who occupy the lowlands and most of the hill regions of the Sicsola, look down on their neighbors the Cabecars and treat them as inferiors. The Cabecars, on the other hand, tacitly acknowledge even a social supremacy, and in a mixed party submit to assume the more menial occupations, like bringing water and wood; and are always obliged to wait until the last when food or drink is being served. Few of the Bri-bris speak the Cabecar language, but there are few of the Cabecars who do not speak Bri-bri, and they usually use it in the presence of strangers. The Cabecars have no chief of their own, but are entirely under the rule of the Bri-bri chief, and have been, from time immemorial. Their subjugation is, in short, complete. At the same time they have the honor of religious supremacy, in so far as that the high priest, the "*Usekara*," whose office will be explained further on, belongs to their tribe. The ordinary priests, the "*Tsugurs*," who, like the "*Usekara*," are hereditary, come from a group of families on the Coen River, but belong to the Bri-bri tribe.

About the beginning of this century there was a bitter war between the Bri-bris and the Tiribis. The youngest members of the war parties are now mostly dead, and the few remaining survivors are very old men. The last of the warriors proper, mature men at that time, died about 1860, at an extremely advanced age. I have heard the traditions from both sides the question, and of course each party throws all the blame on the other. The Bri-bri story is that some people, a whole family, living on the extreme eastern portion of the Uren district, were found murdered, and no clue discovered to the perpetrators of the act. Not very long afterwards other murders occurred in an equally mysterious manner, which threw the whole country into a state of excitement. Afterwards a small party was attacked by some unknown Indians, a portion killed and some left to tell the tale. The tracks of the strangers were followed through the woods, always keeping to the east, until they were lost. Following this clue, the chief of the Bri-bris sent out a party of armed scouts, who climbed to the summit of the dividing ridge, overlooking the Tilorio. From here they discovered for the first time that they had neighbors; seeing their houses and cornfields in the distance. A large war party was fitted out; they passed the mountains, and without warning descended on the unsuspecting

enemy, killing large numbers. After this a desultory warfare was kept up; each party striving to take the other unawares, and to capture as many heads as possible. This went on until the Tiribi, reduced to a handful, sued for peace and submitted as a conquered people to the Bri-bris. Since then, the chief of the Bri-bris has always retained the right of final choice of chief of the Tiribis, after nomination of the candidate by his own people. Beyond this, no actual control has ever been exercised. The Tiribi story does not differ from the above, except in the origin. It throws the blame of the first aggression on the Bri-bris. In some respects the Tiribis are superior to the Bri-bris. The children are more respectful to their parents; the women are more modest in dress and behavior, and the men are more industrious. This is their boast, and while they look down on the Bri-bris, the latter despise them as a conquered people. Very little communication occurs between the two tribes, and I could learn of but two cases of intermarriage between them.

I have already said the Tiribis and Cabecars are under the political rule of the Bri-bris. The form of government is extremely simple. One family holds the hereditary right of chieftainship, and up to 1873 the reigning chief had theoretically full powers of government. The succession is not in direct line, but on the death of the incumbent, the most eligible member of the royal family is selected to fill the vacancy. Often a son is passed over in favor of a second cousin of the last chief. The present chief is first cousin of his predecessor, who was nephew of his predecessor, who was in turn a cousin to his.

Formerly the chiefs held only a nominal control over their people. The principal advantages derived from the position were rather of a social than a political nature. The chief was conducted to the best hammock for a seat on entering a house. He was treated to their great luxury, chocolate, when persons of less note were fain to be content with chicha. But in case of a quarrel the chief had to defend himself from the blows of the long, heavy fighting-stick like any ordinary mortal. Within the last decade or two, the traders, by throwing their influence on the side of the chief, have caused him to be treated with more respect, and endowed him with the attributes of a judge over his people, in all ordinary disputes. About 1870 or 1871, Santiago, the then chief, paid a visit to Cartago and San José; was well treated, and received an appointment from the Government, for the position which he already held, with the full approval of his tribe. It had been customary for the heir-apparent, the future successor, to hold a position as second, or subordinate chief, with little or no authority. One Lapiz was at that time second chief, and claimed that he was more entitled than the other to the chieftainship. Exaggerated ideas of great mineral wealth in "Talamanca" have been long held in Costa Rica and the Commandant of Moen, a little settlement on the Atlantic coast, used principally as a penal station, conspired with Lapiz against Santiago. This individual, named Marchena, advised Lapiz to assassinate his chief, and thereby place himself at the head of the tribe.

It seems that Marchena's plan was to put a creature of his own over the Indians, so as to gain access to the supposed rich mines and thereby benefit himself. Instigated by a "Christian," the savage, nothing loth, conspired with his people, but Santiago learned of it and made efforts to arrest him. Learning of this, he fled to the mountain fastnesses of Bri-bri where, broken down by disease and hardships he died, leaving, Indian like, his revenge as a legacy to his adherents. Santiago, who was a drunkard and, when intoxicated, a tyrant, gradually enstranged his people from him, and his relatives, Birche and Willie, placed themselves at the head of the opposition. The occasion sought for was not long in being found, and one morning Santiago was shot in the woods by an ambushed party, who at once took possession of the government, burnt their victim's house, appropriated his effects, including his three wives, and defied his friends. Birche, as the oldest of the two cousins and claimants to the chieftainship, took precedence and Willie became second chief. Mr. John H. Lyon, an American from Baltimore, who had lived in the country since 1858, had acted as secretary to Santiago, and only their respect for an upright man who had always treated them justly, coupled with the fact that he was not a "Spaniard," prevented them from venting their resentment on him, in common with the other friends of the murdered man. He remained at his house for some weeks despite the storm. But at last, thinking discretion the better part of valor, he left the country with his Indian family and remained absent some months. On his return he found matters settled after a fashion: the Birche party in power, but by no means secure against an outbreak from the friends of Santiago, who only wanted a leader. They urged Lyon to head them but his better council prevailed, and they perforce accepted the situation. I visited the country first in March, 1873, accompanied by the Commandante of Limon, Don Federico Fernandez. He then formally approved of Birche as chief, Willie as second, and re-appointed Lyon as Secretary. This was a great step in advance for Birche who now, for the first time, felt himself secure. The assassination of Santiago was practically ignored, but they were told "to be good and not do it again." This was succeeded by an infinite number of petty quarrels between the two chiefs; each disliking the other, and each wishing the other out of the way. By dint of constant interference on the part of the foreigners, they were prevented from coming into actual collision, although one attempt was made by the friends of Willie to kill Birche, Lyon, myself and my assistants at a blow by planting an ambush for us on one of our journeys. However, in December, 1873, business taking me to San José, I induced Birche to accompany me. On my advice, Don Vicente Herrera, the Minister of Interior, gave to Birche a formal commission as "Jefe Politico" of Talamanca, confirmed Willie as second chief, and appointed Mr. Lyon "Secretary and Director of the tribes," fixing suitable salaries for each. This was the first time that the tribe had formally submitted to the Costa Rican government. The action of Santiago was purely an in-

dividual affair, and looked on with great disfavor by the tribe. Matters went on very well for a few months under the new regime. But Birche, a man of little capacity, at the same time a coward and a tyrant, could not be content with his position. He began a system of ill treatment against which the people grumbled, but which they feared to resent. At first both Lyon and myself tried to quiet the complaints, believing that punishment had been justly inflicted, and knowing that

> "No man e'er felt the halter draw
> With just opinion of the law,
> Or held with judgment orthodox
> His love of justice in the stocks."

But it soon became apparent that his majesty (they are always called king) was abusing his power. The Indians dared not quarrel with Birche, for fear of offending the government, but came to Lyon almost daily with complaints. At last we decided to effect a change. Birche went to Limon to draw his salary, and at the same time to complain of a purely personal quarrel with Willie, in which he had fared worst. I arrived there a few days later, having completed my exploration, and being on my way to the Capital. On being asked for information and advice by the Commandante, I told the story and urged his removal. This could only be done by the minister, but he was suspended until the decision of that officer could be obtained. In a few days I saw Mr. Herrera, and after a conversation he decided to endorse the Commandante's action. Birche was accordingly removed, Willie was given a nominal chieftainship, and Lyon instructed to assume all responsibilities. Thus in less than two years the people have, without knowing how it happened, been deprived of their hereditary chiefs, and a foreigner placed over them. Willie remains with the empty title of chief without even the power to issue an order or punish an offender, except when ordered by Lyon. This gentleman has their entire confidence and respect, and many of the Indians begged to have even the title taken away permanently from the "royal" family. I have been thus prolix on this branch of the subject, because I was an eye witness, a participator, in the latter part of the events I relate. Trivial as they are, they may interest some, throwing light on the manner in which one tribe after another is subdued.

A strange fatality seems to hang over these Isthmian Indians. Even when not brought into contact with the debasing influences of civilization, the tribes are visibly diminishing. Less than two centuries ago, the population of Talamanca, as Costa Rica calls her southeastern province, was counted by thousands, now barely 1200 souls can be found. The Shelaba tribe is extinct; the Changinas are at the point of extermination, the Tiribis number but one hundred and three souls, and Lyon tells me that the Cabecars of the Coen have diminished fully one-half within the last seventeen years, while the decrease in the Bri-bris is hardly less rapid.

During my travels in Talamanca I collected in each district an accurate

enumeration of the population. My process was to get together several of the most intelligent and well-informed men in the district; cause them to compare notes and then to tie a series of knots in strings as they are accustomed to do; different kinds of knots distinguishing the sexes. Each house was counted separately, so that I obtained an exact census of the whole country with the following results. This cord census is now in the museum of the Smithsonian Institution, with many other articles, illustrating the life and customs of the people.

The population of each district is as follows:

Tiribi	103
Uren	604
Bri-bri	172
Cabecar	128
The Valley	219
Total	1226

This covers all of the water-sheds of the Tilorio and Tiliri rivers except two small bands; the Changiuas on the Changina branch of the Tilorio and a refugee remnant of the Cabecars on the extreme head of the Tiliri. Probably an additional hundred would cover all of these.

On the North or Estrella river, and on the Chiripo, there are a few more Cabecars who have little communication with the headquarters of the tribe, but who are in the habit of going out to Limon or Matina for what little trade they require. These are probably in all, not more than 200 or 300 in number. Nearly all speak Spanish and they are gradually approximating to civilized or semi-civilized ways.

The cause of the rapid decrease in the population is their extreme indolence. With a country fitted to produce all the fruits of the tropics; where maize grows luxuriantly, and where cattle and pigs increase without care or labor; they are content to make plantains their staple, and almost their only food. Chicha the form in which most of their maize is used, is a beverage very slightly intoxicating, if drank in large quantities, but the amount of nutriment derived from it is unimportant. Meat, whether of domestic or wild animals, is a rarity and a luxury, and the banana or plantain make up all deficiencies. The natural consequence of a bulky and comparatively innutritious diet is a low physical state. The system has little resisting power against disease, or healing power over wounds. A slight attack of coast fever, which, with an ordinary strong man of our own race, would be comparatively harmless, is very apt to terminate fatally with these people. Indolent ulcers are so common that perhaps a full fourth of not only adults, but even children have them, usually on the legs, originating in some slight scratch or bruise; and very few of the elderly persons are without their scars. These ulcers often last for years, and I have seen them as broad as the two hands opened side by side. Although the local diseases are few, the entire absence of medical treatment, the ignorance of the first principles

of hygiene, and the universal negligence of the sick, on the part of the well, all contribute to shorten the average life-term of the people, so that very few old men or women are to be found, and the mortality is so great among the young that the deaths more than counterbalance the births. Unless some great change takes place, the whole of the tribes of Talamanca will have disappeared within two or three generations more. The Tiribis, who like the others have strict rules about marriage, within certain degrees of consanguinity, are now so reduced that several young men and women are to-day forced to remain unmarried for want of proper mates sufficiently removed in relationship. But at the beginning of this century they were powerful enough to give battle to the Bri-bris. The Changinas and Shèlabas have disappeared and the fate of the other tribes requires no prophet to foretell.

Physically, the people of all the tribes bear a strong resemblance to each other. They are of short stature, broad shouldered, heavily built, full in the chest, with well-formed limbs, and well muscled throughout. Their color is similar to that of the North American Indians, or, if anything different, perhaps a little lighter. There seems to be but little, if any admixture of foreign blood among them. Their history would hardly lead us to expect it. They have lived very exclusively, and it has hardly been half a century since they have ceased to live in a state of open war with all intruders from the coast side. The Spanish occupation closed so disastrously over a century and a half ago, was of too short duration, and and the whites were too few, to make a permanent impression on a then populous country.

The following measurements taken from my servant, a full grown man, who is not more than an inch, if so much, under the average height, will give a fair idea of their build. He measures in height, 5 ft. 1½ in., circumference of chest, under the arms 35¾ inches; of hips 34 inches, of waist 33¼ inches, length from axilla to tips of the fingers, 24½ inches; leg, from the groin to the ground, 29 inches. Both sexes are marked by an almost perfect absence of hair from all parts of the person except the head; where there is a dense growth of coarse, straight black hair. This the women plait with considerable taste. The men wear theirs cut moderately long and of an even length all round; or a few retaining an older fashion, have it a little over a foot long, apparently its entire natural length, and either let it stream loosely over the shoulders, gather it into two plaits, or twist it into a roll, bound with a strip of mastate, and coiled at the back of the head in a round flat mass.

The breasts of the women are not conical, as occurs with many, if not most of the Indian races; but are fully as globular as those of the European or African. Nor are they directed laterally. They are not generally large, though some marked exceptions occur to this rule. But they have one strongly marked peculiarity. The entire areolar area is developed into a globular protuberance, completely enveloping and hiding the nipple. The development of this part begins with, almost

before, that of the mammary gland proper, on the approach of puberty, and is more obvious then, than after the gland has acquired its full rotundity. After marriage, the areola gradually sinks, leaving the nipple standing out prominently in its centre.

In treating of the manners and customs of these people, I shall include the three tribes of Tiribi, Bri-bri, and Cabecar as one, and shall only mention them separately where points of difference occur. First in the order comes the birth of the young savage.

All the world, or rather all the ignorant world, and even a part of that which considers itself reasonably enlightened, entertains a belief in the influence on the child, of certain impressions made on the mother during pregnancy. Doubtless the general mental state of the mother has an influence on her progeny. But the belief exists among these Indians, in its full force, that the sight of certain objects by the mother will influence her child physically. They go further. The mother is given to wearing certain charms to that end. The eyes of the fish hawk give the future fisher the power to see his prey beneath the water; the teeth of the tiger (also worn by both sexes for purely ornamental purposes), when used as an amulet makes the future hunter swift and strong in the chase; the hairs of a horse make him strong to carry loads, and a piece of cotton pushed inside of her girdle by a white man, is certain to make the child of a lighter complexion.

When the time of parturition approaches, the father goes into the woods and builds a little shed, at a safe distance from the house. To this the woman retires as soon as she feels the labor pains coming on. Here, alone and unassisted, she brings forth her young. Difficult delivery is as rare as among the lower animals. As soon as the delivery is effected, the mother of the woman, if present, and in her absence, some other old woman approaches the mother and, with great circumspection to avoid the defilement of *bu-ku-ru'*, of which I shall speak further on, places within her reach a piece of wild cane, so split as to make a rude knife. The mother ties the umbilical cord and severs it with this knife. No other kind is permitted. She is also supplied in the same manner with some tepid water in a folded plantain leaf, in which she washes the child. She then collects the after-birth, &c., and buries it, after which she goes to the nearest water and bathes herself. An *awa*, or medicine man then appears on the scene. He causes the mother to theoretically wash herself again, by dipping her fingers into a calabash of water, which he forthwith drinks. He then lights a pipe of tobacco, blowing the smoke over her. He then purifies himself by washing his hands, after which, and not before, all are permitted to return to the house. The recovery of the mother is so prompt that it may be more properly said, she has nothing to recover from. I have seen a young mother, with her first child not yet a week old, attending to her ordinary duties as if nothing had happened.

The matter of names is very loose and arbitrary. It is almost impossi-

ble for a stranger to learn the true name of an Indian, directly from the person himself, although his friends may divulge it, and this is looked upon almost in the light of either a breach of confidence, or a practical joke. After long acquaintance, they may be prevailed upon, but even then are more apt to give a false name than to tell the truth, so great is their reluctance. One fellow, who was my servant for over three months, after always denying having a name, at last told me a pet name, or "nick-name" that he had had as a child. It is customary for children to have provisional names, or to be called only "boy" or "girl" as the case may be, until the whim of an acquaintance or some equally arbitrary circumstance fixes a title to them. Besides the native name, generally derived from some personal quality, or not seldom the name of some animal or plant, almost all of the Indians possess a foreign name, by which they are known, and which they do not hesitate to communicate. Among themselves, when the name is unknown, a person is called by the name of the place where he lives. Mr. Lyon says all the women have names, as well as the men. But my experience with them is never to have heard them called by other titles than "girl," "woman," "*wishy*" (applied familiarly to young married women), or "so-and-so's wife" or daughter, except in the case of a few of the more civilized men, who have given Christian names to their families.

Children are not generally weaned early. In case of the birth of a second child, the first is weaned perforce. But it is nothing strange to see a child well able to walk, say even two years old, go to the breast as a matter of course, although sufficiently accustomed to more solid food.

Small babies are carried on the back, astride the hips of the woman, and supported by a broad strip of bark or cotton cloth, passed around both, and secured in front by a dexterous tucking in of the ends. When they become larger, they are carried on one hip, supported by the arm; or are placed on top of the load, if the mother is traveling. They sit perched on the bundle, with a foot dangling either over or behind each shoulder of the mother, and soon learn to hold on like monkeys.

The training of the youth is left almost entirely to themselves. Among the Tiribi they are taught to respect and obey their parents, but in the other tribes they are more insolent and disrespectful to their parents than to other persons. I have seen a boy of ten years old absolutely refuse to obey some trifling command of his mother, and she seemed to have no power to enforce her order. The little girls learn early to accompany the older girls and women when they go out to bring water. Their usual station, in the house, is at the side of the fire, where, as soon as they are large enough, they assist in fanning the fire, preparing plantains for the pot or watching the cooking. The boys will sometimes deign to hunt fire-wood, but they are more apt to be playing by the side of the river with mimic bow and arrow, learning to shoot fish under water. Their toys are mostly diminutive copies of the tools and weapons of more advanced age. The machete of the man is represented by a good sized

knife, often the only article worn by the boy; the long hunting and fishing bow is foreshadowed by one a yard long, perhaps made of a simple piece of wild cane; the blow gun, a tube longer than the person, is in constant use; and I have seen some few actual toys such as a top made of a large round seed with a stick through it; and a rattle differing only in the degree of care in the making, from those used by the priests in their incantations.

The arrival of puberty is the signal for marriage, at least on the part of the girls. The courtships, if such they can be called, are carried on principally at the chicha drinkings, and I am assured that very few young women retain their virginity until marriage. A plurality of wives is allowed at the option of the husband. Many have two, and some three women. When a young man wishes to marry, having arranged with the girl, he applies to the father. The consent is practically a foregone conclusion; but the details of the bargain must be arranged. In most cases, the groom goes to live at the house of his father-in-law, becomes, at least for a time, a member of the family, and contributes with his labor to the common support. Girls are thus available property to their families. But in case the man already has a wife; is in short, settled in life, and has his own home, he may not want to change his residence. He then compounds with the family; giving a cow, a couple of pigs, or other equivalent for the woman, in place of his services. No form of ceremony is required, and the marriage lasts as long as it suits the convenience of the parties. In case of infidelity on the part of the woman, or undue cruelty on the man's part, they may separate. Sometimes, if the woman is unfaithful, the man whips her severely, and perhaps returns her to her family, or she, in a fit of resentment, leaves him. This may be for a year or so, or may be final; but during such separation either party is at liberty to make new connections, thereby remaining permanently apart.

Probably there is no better place to mention kissing than in connection with courtships and marriages. This agreeable custom seems to be entirely unknown. I have never seen one person among them kiss another, not even a mother her child.

There are certain limits within which parties may not marry. The tribes are divided into families, or something analogous to clans. Two persons of the same clan cannot marry. This is now a source of difficulty among the Tiribis. The tribe is so reduced that a number of marriageable persons of both sexes are unable to find eligible mates. I could not ascertain exactly how the question is settled as to which clan a person belongs, whether he inherits from father or mother, but so far as I could gather, I think from the father. Cousins, even to a remote degree, are called brother and sister, and are most strictly prohibited from intermarriage. The law, or custom, is not an introduced one, but one handed down from remote times. The penalty for its violation was originally very severe; nothing less than the burial alive of both parties. This

penalty was not only enforced against improper marriage, but even against illicit intercourse on the part of persons within the forbidden limits. Mr. Lyon related to me a case that occurred since he has been living in the country, where the power of the Chief Chirimo was insufficient to protect a man who married his second or third cousin. Fortunately for the delinquents, they succeeded in making their escape, though with difficulty, being followed two or three days' journey by the avengers.

Infidelity is not rare, and the husband has the redress of whipping the woman and dismissing her if he desires, and of whipping her paramour if he is able. But so cautious are the people about the blood limit of intermarriage, that a woman on giving birth to an illegitimate child, for fear that it will not know the family to which it belongs, will usually brave the punishment, and at once confess its paternity.

As cousins are called brother and sister, so are not only the brothers and sisters, but even the cousins of a wife or husband all called indiscriminately brother and sister-in-law; so that a person may on a single marriage find that he has annexed fifty or a hundred of these interesting relations.

On the death of the head of the family, the next oldest brother, or in default of a brother, a cousin or uncle assumes his place, and is then called father by the children. This does not involve any especial material duties, such as the support of the family; but is rather a sort of honorary title; giving him, however, the ruling voice in any family council or discussion.

On the death of an individual; if a young person, a woman, or a person of but little consequence, the body is prepared as soon as possible in the manner described below, and carried to the forest; but if a person of more consideration, there are some preliminary ceremonies. These I had the opportunity of witnessing in the case of an old man who died on the Uren when I was present. He belonged to one of the distinguished families, an ancestor, perhaps his father, having been one of the leaders in the war with Tiribi, and he the heir to, and possessor of, one of the few gold "eagles," or insignia of rank. He died in the night, and next morning, the body being in his hammock, covered with a piece of bark cloth; all of the chicha, chocolate, and food that the poor people of the house could get together on short notice were prepared. A fire was lighted, amidst singing, by twirling a pointed stick in a socket on the face of another. This was the sacred fire, which was communicated to a small heap of wood placed on one side in the house. This could be used for no common purpose whatever. No ordinary fire could be lighted from it; not even could one use a stick of it to light his pipe. It must burn continuously for nine days. In case of its accidentally going out before that time, it must be relighted in the same manner as at first; and at the end of that time, only a priest could extinguish it, and he only with a calabash of chocolate, and during, or at the end rather, of the suitable incantation.

The custom of burying or otherwise placing with the dead all of his valuables, evidently existed at one time with these people. The Tiribis, who bury their dead, did so, up to within the memory of persons still living, and all matters that could not be buried, like live stock, fruit trees, &c., were ruthlessly destroyed. A more practical method has grown up with the present generation, and they now divide the property of the defunct among the heirs, with as much avidity as in more enlightened communities. So do the Bri-bris and Cabecars, but these compound with their consciences. Whether the Teribis have a similar custom, I am not prepared to say, not having seen a funeral, and having no information that I consider sufficiently trustworthy.

The next step after lighting the fire, was for the master of ceremonies, appointed by mutual consent, to cause to be collected some small scrapings of a peculiar wood, called Palo Cacique by the Spaniards. It is a wood used only for walking sticks, and will be again referred to in that connection. He also obtained a large lump of cotton wool, some seeds of a species of pumpkin, and a small root of sweet yucca. All the male friends of the deceased present, seated themselves on low benches in a double line, facing each other, with another bench between. A part of the cotton, spread out so as to make a bulk about the size of a man's hand, was placed in front of the principal person, who then began in a sing-song tone between a recitation and a chant, to relate the merits and deeds of their departed brother. As he proceeded, and mentioned for instance that he had planted much corn, he laid carefully on the cotton a piece of shaving which he said was the "planting stick" used in that operation. Another laid aside of it a piece of pumpkin seed, which represented the corn. Another taking up the song, related how he had shot fish, and another shaving was the arrow. An impromptu string a couple of inches long, twisted out of the cotton, and stained red with the powder from some annatto seeds, was a rope with which he had led a cow, bought years before in Terraba. This lasted for an hour, until every tool or weapon he had ever used was represented by a little pile of seeds and shavings on the cotton. But he was a great man and his "eagle" was not to be forgotten. A very rude imitation of it was cut out of the skin of the yucca root and placed on top of all his other property, and then the edges of the cotton were doubled over making all into a ball. This was placed on his breast, next his body, and he was thus armed and equipped with all he had used or owned in this world, ready for use in the other; and his heirs none the poorer.

The body was then enveloped in the piece of "mastate" or bark cloth that he had used as a blanket, together with the hammock in which he swung. A quantity of "platanillo" leaves, a leaf not unlike that of the plantain, but only half the size and much tougher, were placed on the ground, two or three deep. The bundle was laid on this, the edges of the leaf envelope, doubled over, and dexterously tied by strips of bark string and the whole turned out a very respectable Egyptian mummy done in

green. By means of three strings, this was swung under a pole, ten feet long, raised on the shoulders of two men, who trotted off unconcernedly to the woods a mile or so distant. They were accompanied by two or three more, armed with machetes.

A little boy whom I had for a servant for a few months, died on one of my journeys. We watched by him and did all in our power to save him, and were assisted by two of our men, one of whom was an "*awa*" or doctor. As soon as we saw that he was dying, and I had given up the last hope, the *awa* took charge. He motioned us all off. From that moment the moribund becomes unclean and only the *awa* can touch him. As soon as we pronounced him dead, the doctor covered him up. Next morning, the death taking place about midnight, without ceremony he was bundled up in his blanket and the usual leaves, and carried off in the same manner to the bush. But he was of no consequence. Only a boy who was nobody and had done nothing. I mention this case to show the difference in treatment, according to the person.

Next to a woman in her first pregnancy, the most *bu-ku-ru'* (unclean) thing is a corpse. An animal that passes near one after it is placed in its temporary resting-place, is defiled forever, and must be killed, as unfit for food. Accordingly, an unfrequented spot is selected, where tame pigs or cattle never go. Here a low bench is made of straight sticks, about the size of a coffin, raised a foot or two from the ground ; it is carefully fenced in ; the corpse is laid on it, and the whole is then covered with another horizontal layer, making a sort of box, carefully bound together with vines. Over all, a pile of branches and brush-wood is thrown so that buzzards and other carrion-eating animals cannot obtain access to the body. The body remains here about a year, to allow complete decomposition.

In the meantime, the family, or next of kin, on whom devolves the responsibility, proceeds to secure a sufficient number of animals, pigs, or beeves, according to the importance of the defunct. He also plants a corn-field, to supply the material for the chicha. About a year, more or less, after the death, one or more priests are engaged. Generally one is sought and he selects his assistants. For an ordinary person, one is sufficient; while for a chief, or person of distinction half-a-dozen are hardly enough. The chief fixes the time when he will be ready. Another official, a steward, called *Bi-ka'-kra* is also engaged. This latter personage takes entire charge as commissary and master of ceremonies. Under his direction, the corn is ground for the chicha. The number of bunches of plantains that he orders, is obtained ; the animals are killed and cooked as he directs ; and the food and drink are served to whom, and in what quantities he designates. The host resigns all to him and becomes thenceforth merely a guest, until all is over.

When the day approaches, a party goes to the place where the body was deposited. One person, set apart for similar unclean work, opens the package, cleans and re-arranges the bones and does them all up in a

bundle about two feet long; enveloped in a piece of cloth of native make, prepared by being painted in an allegorical manner.

These cloths, about four feet long by two wide, are painted with a red vegetable juice, in figures two to four inches long. The devices vary according to the cause of the death of the individual; whether it be from fever or other disease, old age, snake bite, wounds, &c. One of these cloths, in the Smithsonian museum, is painted for a person who is supposed to have died from snake bite.

The bones, having been tied up in the new bundle, are carried, again under a pole, to the house where the feast is to be held, and are there placed on a little rack overhead, out of the way of persons passing underneath.

Everything being ready, the first installment of food cooked, the chicha brewed, and chocolate boiled, the feast begins.

I had the rare good fortune, not only to witness the ceremony at the death of the persons mentioned above, but also to be present at the death feast of the chief Santiago. That is to say, I saw all that happened on the first and the last days; the intervening thirteen or fourteen being all alike; a succession of eating, drinking, dancing; a disgusting scene of carousal and debauch that did not possess even the merit of variety.

The feast was held in a large house, adjoining the residence of the chief Birche. The house is about seventy-five feet long and forty wide; the ends being round, and the only light entering by the large doorway left open at one end. A little rack, made of wild cane was tied up to the sloping side of the house, about eight feet from the floor, and on this was laid the bundle containing the disjointed skeleton of the murdered chief. At a given signal, the principal singer or priest took his position on a low stool, flanked by the other priests and some volunteers. All were regaled with chocolate served in little gourds. The priest began a low chant and two men started twirling the stick to light the fire. As fast as one tired, another took his place until the sparks glowed in the pit bored in the lower stick. A yell from the priest announced this, and a piece of cotton wool was ignited from the burning dust; with this the fire-wood, previously prepared, was lighted and the fire placed under the remains. Here it was kept up until the end of the feast. After the lighting of the fire, singing and dancing began in earnest, interrupted occasionally by eating and drinking.

The dances are very similar; the principal differences visible to an observer are in the disposition of the dancers, whether in a circle or in one or two straight lines. In the latter case, the two lines are parallel, and the dancers face each other. The dancing is kept up to the "music" of small drums, carved out of a solid piece of wood, with a single head, made of the belly skin of the iguana; the other end is open. The drum is held under the left arm, and is beaten with the tips of the fingers of the right hand. The drummers, ranged in a line, sing a monotonous song, with a chorus; the time being beaten on the drums. Sometimes a

dried armadillo skin is scraped with a large bean-like seed; in the same manner as I have seen the negroes of the West Indies scrape a roughened calabash with a bone. The dancers clasp each other over the shoulder, around the waist, or hook arms; both sexes taking part in the dancing, but not in the singing or drumming, these being the especial province of the men. The steps are usually about three forward and to one side, and then the same number backward. When arranged in a circle, this carries them gradually around the musicians. When in a straight line, they keep on the same spot. The songs are a sort of recitative, sometimes impromptu, sometimes of fixed words; the chorus a sort of "fol-de-rol," a series of meaningless syllables. These songs for dancing must not, however, be confounded with the sacred songs of the priests, of which I shall have occasion to make fuller mention in the proper place.

The dances are kept up nearly all, and sometimes all night at the funeral feast; the participants retiring from time to time and sleeping an hour or two when exhausted, and returning with renewed vigor to chicha drinking, eating, and dancing. It is particularly on these occasions, when the older people are too drunk, or too busy to keep strict watch, that the younger folks manage to evade their vigilance and ——. These eminently practical courtships almost invariably precede the asking of the father's consent by the would-be bridegroom.

After more than two weeks of this license and debauchery, during which three cows, about a dozen pigs, hundreds of bunches of plantains, several quintals of rice, and hundreds of gallons of chicha had been devoured, the *bi-ka-kra* or steward announced that the commissary had given out and the riot must come to an end. I was notified according to previous agreement and went at the time appointed. As distinguished guests, our party of four were shown to the best hammocks, where we were seated, and in a few minutes served with cups of chocolate. In a little while, all of the priests seated themselves on low benches, the leader in the middle. The lay chorus singers were ranged in a double line facing each other and below the priests. The fire was carefully carried from its place under the corpse and piled almost between the feet of the principal priest. All drank chocolate and the priests sounded their rattles. The leader began a low dirge-like song in the sacred jargon, which I was told described in detail the journey of the defunct to the other world. It told of the dangerous rivers he had to cross, where alligators lay in wait to devour him; of the great serpents who disputed his path; of the high hills he had to climb with weary steps; of the fearful precipices he must scale; of the beautiful birds with sweet songs, compared with which even the flute-like *silguero* was as a crow; of the gorgeous butterflies that lightened up the path like flying flowers, and finally of his safe arrival at the country of the great *Si-bu*, where he would have nothing to do but eat, drink, sleep, and enjoy himself.

The song was divided into stanzas, and the priests all followed the lead of their chief, the words being a series of set phrases, but in a language

in part unintelligible to the uninitiated. At the end of each stanza was a chorus, where the priests, who during the stanza kept time with their rattles, now gave a peculiar twirl, and the lay singers joined in the chorus.

As the song approached its end, the leader was furnished with a big gourd of steaming chocolate, holding about a quart. As he finished, landing the dear departed safe beyond further troubles, he announced it with a most unearthly yell, in which all hands joined; he at the same time turning the chocolate over the fire, totally extinguishing it. The party at once arose and for a minute or two all was bustle and confusion of preparation.

A person, whose office it is to handle the dead, endeavored to lower the bundle but it was a little out of his reach. Nobody else could touch it for fear of defiling himself. To lend a hand would have cost an Indian three days of purification. I drew my long knife, which all learn to carry in this country, as an actual necessity; and with a couple of blows cut the fastenings and brought the little cane rack, bundle of bones and all, tumbling into the outstretched arms of the official, with much more haste than solemnity. Nobody seemed shocked, and being a foreigner, and withal a medicine man, who had made cures where their best doctors had failed, I was of course impregnable to *bu-ku-ru'*. The aforesaid official now lashed the package to its stick, and two long slender strings of loosely twisted cotton were tied to the head of the package.

Santiago had had three wives. One of them had re-married to his successor; but there were two remaining in widowhood. A procession was formed. First came the priests with their rattles. Next the chorus singers with their drums. Next the corpse, borne by two men, and preceded by the two widows, each holding the end of one of the cotton strings, leading the dead, as it were, to his final resting-place. Next ourselves, as the most distinguished persons present, and escorted by the two chiefs. Behind us came the older men, and following them the usual rag, tag, and bob-tail of young men, women, boys, and persons of no account generally. Some of the boys however, true to boy nature, were as usual irrepressible, and instead of keeping decorously in place, skirmished ahead, and on the flanks of the procession, mounting stumps, logs, or other commanding points to take in the general effect of the pageant. As the procession filed out of the house, some old chicha jars were carried out and ostentatiously broken; but I observed that nothing of real value was destroyed. As soon as the line got fairly under way, the priests struck up another song which was kept up until the procession halted.

Everybody had been on so long a debauch that it was decided to take a rest of three or four days before the party started off. But it was necessary that the bones should be removed from the house. A temporary ranch had therefore been built a few hundred yards distant; and to this the remains were carried and deposited until the bearers were in a fit condition to proceed.

The final disposal of the remains is a matter of great care. The whole of the tribe goes to the district of Bri-bri for this purpose. The receptacle is a square pit, about four feet deep and ten feet square. This is paved on the bottom with stones, and is roofed over from the weather, by a series of heavy hewn slabs of a very durable wood, open on the front and ends, and sloping to the ground at the back. Each family possesses one of these pits and here, after the funeral feast, the bundle of bones is carried and deposited. After the rest, the remains of Santiago were carried to the "royal" pit and deposited without further ceremony.

The Cabecars, according to Mr. Lyon, have about the same ceremony, but their pits are mere holes, not paved, and covered by planks laid on the ground level.

The Tiribis have a death feast, but it differs in some respects from the others. The body is buried immediately after death, but no longer with the property of the deceased, and, of course, the defunct is not present at his final feast, as with the Bri-bris.

Mr. Lyon, to whom I owe much of the information in the present memoir, has described to me one circumstance, in connection with these death feasts, that I have not witnessed. The warriors among the Bri-bris, who fought in the war with the Tiribis were honored with a little different ceremonial. They are now all gone, and the ceremony is extinct. At the death feast, a person entered, clad in a long gown, wig, and mask. The gown and wig were made of mastate, or bark cloth, covered with "old man's beard" moss, sewed all over it, making a shaggy and nearly shapeless mass. The mask was made of half a "tree calabash," properly fixed up with a wax nose, &c. A copy of this entire dress was made for me by an old Indian, and is now in the Smithsonian museum. The person thus accoutred, took part in the dance, made free with the women and scared the children without let or hindrance. Mothers with young children took them to him and placed them for a moment on his shoulder, "to prevent the evil spirit from doing them harm." Neither Lyon nor the Indians could give me a very clear account of what spirit, whether good or evil, this represented. But the people seemed to regard him as rather of the malevolent sort; to be classed under the general head of "*Bi*" or Devil. Doubtless this, at one time had a distinct meaning, now lost.

No strictly religious belief can be said to exist among these Indians, in the sense that it is usually understood among us. They have, however, a series of ideas or beliefs which affect their daily lives and are never lost sight of. In connection with the funeral feast, described above, I have referred to their idea of a future state.

During the year that the body lies in the woods, the disembodied spirit prowls around, living on wild fruits, of which the wild cacao is the only one of which I know the name, although others were also pointed out to me. At the end of that time, when the funeral fire is kindled, the spirit is thus attracted to the feast, whence it departs on its final journey.

When I asked an Indian where it went, he responded, to the country of *Si-bu'*, and in reply to the question; where is that? he pointed unhesitatingly to the zenith. On inquiring where the road was, he told me it was invisible to the eyes of the living, but that the spirit (*wig'bru*) could see it.

In the other world there are no troubles, no cares. There is plenty to eat and to drink, of those things that the Indian loves most here. Plantains and corn are never wanting; meat and chicha are always to be had; and chocolate, the luxury, *par excellence* of the Costa Rican Indian never runs out, or becomes scarce as, alas too often, it does in Talamanca. He needs all his arms and implements, but it does not seem that he will be obliged to work. These little discrepancies, the wisest *Tsu-gur* does not attempt to explain. After death, the soul remains wandering about near the corpse until the burial feast. Then, by means of the songs of the *Tsu-gurs* or priests, it makes its journey to the "promised land."

Their superstitions are however, somewhat more definite and tangible since they affect their every day actions. There are two classes of uncleanness, *nya* and *bu-ku-ru'*. Anything that is essentially filthy, or that was connected with the death of a person is "*nya*," anything unclean in the Hebraic or Hindu sense is *bu-ku-ru'*. But *bu-ku-ru'* is even more powerful than it is supposed to be by the Orientals. It suffices not only to make one sick, but even kills. In a party where *bu-ku-ru'* is excited, it does not affect all alike, but only attacks the weakest. *Bu-ku-ru'* emanates in a variety of ways; arms, utensils, even houses become affected by it after long disuse and before they can be used again must be purified. In the case of portable objects left undisturbed for a long time, the custom is to beat them with a stick before touching them. I have seen a woman take a long walking stick and beat a basket hanging from the roof of a house by a cord. On asking what that was for, I was told that the basket contained her treasures, that she would probably want to take something out the next day and that she was driving off the *bu-ku-ru'*. A house long unused must be swept and then the person who is purifying it must take a stick and beat not only the movable objects, but the beds, posts, and in short, every accessible part of the interior. The next day it is fit for occupation. A place not visited for a long time or reached for the first time, is *bu-ku-ru'*. On our return from the ascent of Pico Blanco, nearly all the party suffered from little calenturas, the result of extraordinary exposure to wet and cold and of want of food. The Indians said that the peak was especially *bu-ku-ru'*, since nobody had ever been on it before. Even we foreigners were sick from it, and had any of them gone to the summit, they would have surely died. On one occasion, while buying some implements, I pulled down off a rack, two or three "blow guns" that, from the dust on them, must have lain there undisturbed for weeks, perhaps months. As I reached out my hand, I heared the warning cry of "*bu-ku-ru'*" from all around; laughingly disregarding it, and telling them that *bu-ku-ru'* couldn't hurt us, I began examining them.

Some of the people looked very serious and shaking their heads, said I would see before long, that somebody would pay for it. Two or three weeks after, a fine little Indian boy whom I had with me as a servant, poisoned himself by eating excessively of a kind of wild almond called variously the "bri-bri," or "eboe" nut. There was not an Indian in that party but who firmly believed that it was the *bu-ku-ru'* of the blow-guns that killed him. From all the foregoing, it would seem that *bu-ku ru'* is a sort of evil spirit that takes possession of the objects, and resents being disturbed; but I have never been able to learn from the Indians that they consider it so. They seem to think of it as a property the object acquires. But the worst *bu-ku-ru'* of all, is that of a young woman in her first pregnancy. She infects the whole neighborhood. Persons going from the house where she lives, carry the infection with them to a distance, and all the deaths or other serious misfortunes in the vicinity are laid to her charge. In the old times, when the savage laws and customs were in full force, it was not an uncommon thing for the husband of such a woman to be obliged to pay damages for casualties thus caused by his unfortunate wife. *Nya* (literally filth) is a much less serious affair. As soon as the woman is delivered of her child, she ceases to be *bu-ku-ru'*, but becomes *nya* and has to be purified in the manner already described. All the objects that have been in contact with a person just dead, are *nya* and must be either thrown away, destroyed, or purified by a 'doctor.' He can handle them, but must purify himself afterwards. The persons who assist in preparing the corpse, who carry it to the temporary resting-place, or who even accidentally touch it or the unclean things, are all *nya* and must be purified.

Purification from this latter uncleanness is a simple matter. The person washes his hands in a calabash of warm water, the "doctor" blows a few whiffs of tobacco-smoke over him, and the thing is done. But the former is much more serious. For three days the patient eats no salt in his food, drinks no chocolate, uses no tobacco, and if a married man, sleeps apart from his wife. At the expiration of that time. the warm water and tobacco smoke are called into requisition and the cleansing is complete.

Of Gods, deities, spirits, or devils, there are as follows; the "great spirit" or principal superhuman being is called *Si-bu'* by the Bri-bris and by the Cabecars; by the Tiribis he is called *Zi-bo'*, by the Terrabas *Zŭ-bo'* and by the Borucas, *Sĭ'-bŭh*. A good spirit, from whom nothing is to be feared, he receives a sort of passive respect, but no adoration or worship. He is rather looked on as the chief of the good country, of the future state, but as not troubling himself much about mundane matters. It will be seen, therefore, that in their theology, the entire family of tribes is essentially monotheistic, although they have taken the first insensible step towards a plurality of gods, in the manner so admirably indicated by Max Müller, in his "Chips from a German Workshop." They believe in but one God, and assert his unity with an emphasis worthy of Moslems

and yet their priests give him twenty names, in their songs. These names, so far as I could ascertain, all refer to his qualities. One Bri-bri, whom I had with me as a servant for over half a year, and from whom I obtained much valuable information, particularly in regard to the language, said to me, "Why do you foreigners ask us how many Gods there are? There is only one, and that is *Si-bu'*."

The Devil, or devils, are minor personages, who receive no worship of any kind. They are called, *Bi*, by the Bri-bris and Cabecars, *Au* in Tiribi, *Auh* in Terraba, and *Ka-gro'* in Boruca. The devil is generally malevolent, but does not seem to be specially feared. *Bi* among the Bri-bris is a term also used for a variety of lesser devils, or evil spirits who have special missions, like making people sick, &c. Some of these inhabit the less frequented parts of the forests and mountains, and are very jealous of their domains. People entering an unfrequented region, make as little noise as possible. If they make the local *Bi* angry with their noise, he will revenge himself by a shower or by causing somebody to fall and hurt himself, or to be bitten by a snake, &c. A person who has once been in these places can return with less risk, but all new-comers must keep at least a comparative silence. Another class of beings inhabit the rocks on the summits of certain mountain peaks. They live *inside* the rocks, not among them, consequently their habitations are undistinguishable to mortal eyes. They seem to have the same habits as ordinary humans. One of these peaks, a mile or two across a cañon, in front of a place called Sar-we, is thus inhabited according to the accounts of the people of Sar-we. They told me of hearing singing, the beating of drums, &c., coming from that direction. The configuration of the hills is such that a glance showed me, that a drum beaten at certain of the houses in the cañon of Uren, would echo back from this hill to Sar-we and thus account for the sounds. These people of the *U-jums*, as the naked peaks are called, are said to be the owners of the tapirs which roam through these solitudes. They are very jealous of their domains and cause, by some occult means, the death of any one who dares approach their homes. I could not induce an Indian to accompany us to the summit of Pico Blanco, partly on account of *bu-ku-ru'*, and perhaps more still for fear of the people of the *U-jum* or peak. In addition to these beliefs, they also believe in the efficacy of incantation by their *Awas* or doctors, of whom more immediately; and further in certain ceremonies or observances of their own. I have seen a woman carefully collect a bunch of some weed and taking it to the river wash her face, neck, breast, and arms with it. This was to bring good luck to the men who were at the time at work turning a stream to dry its bed, for the purpose of catching fish. She had her reward; hundreds of fish of 2 to 4 pounds weight were captured, and of a quality as fine as shad.

There is a peculiar wood, of which I shall have occasion to speak further on, used only for walking sticks for the chiefs and more eminent persons. The growing tree is unknown and it is only obtained by the

accidental discovery at rare intervals, of a half-rotten trunk in the woods. It is prized principally for its color, which is between that of old mahogany and rosewood, and which is probably in part due to seasoning, or to some change in the heart, consequent on the decomposition of the surface. When an Indian finds one of these sticks, he marks the spot, but dares not take possession immediately. He must purify himself by a three days fast before he can begin work on it. It is believed that these sticks are under the protection of a poisonous snake, and if the person has not properly prepared himself, the guardian will revenge the outrage by biting him.

The privileged classes, apart from the chiefs, are three. Two of these are hereditary. The *U-se'-ka-ra* is a sort of high priest, and is of nearly as great importance in the eyes of the people as the chief. In fact, the time was, and not very long ago either, when the chiefs themselves made journeys to visit him as suppliants. The present incumbent is a youth of perhaps twenty-five years of age, and is not yet full fledged. His predecessor, his father, died recently, and, until after the funeral feast, he cannot enter fully into the exercise of his functions. The family lives far back in the hills of Cabecar, and, although a member of that despised tribe, has from time immemorial held undisputed sway over both it and the Bri-bris.

The former *U-se'-ka-ra* was very arrogant, and would hold no communication with foreigners. He claimed supernatural powers, and held frequent interviews with spirits. On these occasions he went alone to a cave, several miles from his house, and spent days together there. On his return he would not converse even with his own family. Nobody but his familiar, now a very old man, was allowed to serve him, or even to speak to him for a certain number of days after his return from one of these mysterious journeys. He rarely traveled about, or visited his neighbors. He lived by levying contributions on the people, or by voluntary presents. His only beverage was chocolate, and the cacao was contributed as voluntary gifts from people far and near. If he entered a house, and offered to buy, or expressed even admiration for anything, whether a chicken, a pig, or any other object, it was at once presented to him. It was considered as good as forfeited. If not presented, it would be sure to die anyhow, and his ill-will would be gained besides. In case of any public calamity, like an epidemic disease, or a scarcity of food from drought, the chief only must visit him, and beg his intercessions with the spirits. He would pay no attention to private appeals. In case he felt inclined to be gracious, he would retire to his cave, and in due time after order a fast. The young man who now holds the position, is one of the finest looking men in the country. He is tall and well formed, his good-natured looking face bears an expression of seriousness hardly in keeping with his youth; and his whole bearing is grave and impressive. I was forcibly struck by his manner, being so strongly in contrast with the light-hearted, talkative character of most of the people. When in

Cabecar he visited us twice, and on neither occasion did he speak, except when spoken to, unless it was to make some remark, in very few words, and in a low tone of voice, to some of his attendants. His dress consisted of a white shirt, not over clean, a woven cotton breech-cloth, a bright-red handkerchief, tied in a roll around his head, and a magnificent necklace of four strands of large tiger's teeth. He sold me two of the strings for half-a-dollar, and I presented him with some trifles, among which was the rather suggestive article, a bar of soap. He accepted them without any acknowledgment. But then they don't know how to say, "thank you."

Next in importance are the *Tsu'-gurs*. These are the ordinary priests, and their duties are confined to officiating at the feast for the dead. Like the preceding, they are hereditary; only members of one or two families can become priests, and these seem to have all descended from a common ancestor. I have already described the performances of the *Tsu'-gur* at the death-feast of Santiago, and there is nothing to add in that connection. Other feasts only differ in the less degree of profusion and the shorter time they occupy. But there is one circumstance of which I have said little, and that has always seemed to me mysterious. Unfortunately, from no want of effort on my part, I was not successful in investigating this more thoroughly. The songs of these priests are in a language, dialect, or jargon, whichever it may be called, in great part unintelligible to the uninitiated. Some words used are in the vernacular, but many of the nouns are peculiar. *Si-bu*, or God, has at least twenty names; many natural objects have names peculiar to the priests, and the difference is so great that not only I, with my imperfect knowledge of the language, but Mr. Lyon, who speaks it as well as an Indian, could not understand even the purport of the songs. These songs are taught by rote to the young candidates to the priesthood, and are always rehearsed by the priests apart, before being sung. I made several efforts to obtain a vocabulary, but in each case was defeated, rather by the want of understanding on the part of the priest, than from any unwillingness to impart what they knew. At last I made an agreement with the most intelligent and best informed of them. He was to visit me at a certain time and answer all my questions —for a consideration. But a severe attack of rheumatism prevented his coming and lost me the last chance. I have no theory to offer as to the origin of this singular fact. But two explanations however, seem possible. Either the whole thing is an invention, which I think hardly probable, or the system is an exotic, and the songs are in the original language of the missionary who introduced it. I can hardly express my regret at failing to obtain some clue to so interesting a problem.

Finally come the *Awas*, sorcerers, or doctors. This is an open profession, and since it requires but little preparation, gives certain privileges and standing, and brings occasional emoluments, it is pretty numerously filled. The fellows are an arrant set of quacks, and I do not believe there is a single one who acts in good faith. Nevertheless, the people as a rule

believe in them. Some of the more intelligent or more civilized of the Indians, those who have been most in contact with foreigners, take foreign medicines when sick, but they are the exceptions. Their method of purifying an unclean person has already been described under the heads of child-birth and uncleanness. They also claim to bring or drive away rain. To do this, the doctor must have a pipe full of tobacco, or a cigar. He goes into the open air, smokes, blows the smoke in certain directions, calling out in an imperative tone of voice, "Rain, go to—" whatever place he may see fit to designate. Once when prisoners between two swollen rivers, forced to wait for them to fall low enough for us to ford; one of our few means of amusement was to give one of these fellows, in our suite, a pipe full of tobacco, and set him to clearing up the weather. He would go outside of our little hut, and between the puffs of smoke would call out, "Rain, go to Panama," "go to Chiriqui," "go to Cartago," in short, to every remote place of which he happened to know the name. It took him ten days before his efforts were crowned with success, and when ultimately the blue patches did begin to appear in the sky, he had the effrontery to calmly claim it as his doing! They also claim to "blow" a proposed route of travel, so as to drive away snakes and bring good luck on the route. In this case, the *modus operandi* is practically the same as for the weather. But their master efforts are when charming away sickness. To see the process, two of my companions feigned sickness and called in the services of one the doctors. He caused each one to procure a live chicken. Catching the animal by the neck and heels he made passes all over the body of the patient, in every direction. Any small animal will answer. Sloths, opossums, even young alligators are used, and are said to be equally efficacious.

After some minutes of this manipulation, he lighted a pipe and blew tobacco-smoke at them. Having given them numerous injunctions about diet, such as forbidding the use of coffee, tobacco, pepper, and salt for a day or two, he went outside the house, and spent half the night seated under an orange tree, singing a doleful ditty, enlivened at irregular periods by unearthly howls and groans. His fee for all this was, in addition to the two fowls, used in the ceremony, and which was all he would have received from an Indian, sixty cents from one and forty from the other; the fees being graduated by the gravity of the supposed infirmities. These doctors claim that their powers are based on the magic merits of certain charms they carry about with them. These charms are supposed to be calculi, extracted from the viscera of animals. Our friend, who tried to change the weather, possessed three of these. One purported to be from the liver of a sloth, another from the bladder of some other animal, &c. I examined them with a glass, and am convinced that they were mere fragments of little calcareous veins, common in the metamorphic rocks of the country, and which had been ground smooth by friction. My little knowledge of medicine, and a moderately well-supplied medicine-case, enabled me to make numerous cures, and of course I soon

acquired the title of *Awa*. When asked by my brother professionals to exhibit my charms, I always gravely produced my little pocket compass, which, by its mysterious movements, never failed to impress them. I never could persuade the boldest to touch it.

Three kinds of fasts are observed. The first is only when ordered by the *U-se'-ka ra* on great public occasions. This is general and simultaneous over all the country. Sufficient food is prepared beforehand to last for three days, the usual time fixed. During those three days, no fires are lighted; the food is served and eaten in silence; no unnecessary conversation is allowed; the people stay strictly inside their houses, or if they go out during day time, they carefully cover themselves from the light of the sun, believing that exposure to the sun's rays would "turn them black"; no salt or other condiment is used in the food; no chocolate is drunk, and even tobacco is forbidden. The second kind is similar, though less rigid than the first, and is voluntary; the same restrictions are observed with reference to fires and food, but the people may talk and go out, avoiding, however, carefully all chance of contact with *bu-ku-ru'*. The third is still more limited, and is the individual fast already referred to for cleansing from *bu-ku-ru'*.

The feasts are of two classes; the death feast already described, and re-unions for labor. In the latter case; when a person wants to do an extraordinary piece of work, like clearing a piece of forest for a plantation, he provides a suitable quantity of food, and especially of chicha. On the day appointed his neighbors unite early at his house, or at the spot designated, and work industriously until about noon. All then repair to the house, and, after a good round of chicha drinking, food is served, followed by more chicha. After a while dancing begins, and is kept up as long as the chicha holds out. Sometimes the work is continued for two or three days, but always ends early in the day, the afternoon and evening being devoted to eating and especially to drinking.

No labor can be accomplished without liberal allowances of chicha, and the man who is the most profuse in this respect is the best fellow. A man will sometimes undertake to make his own clearing, unassisted, but it is very slow work, and drags on at the rate of two or three hours' work a day, with many days of rest. The trees once cut down, the man will burn off the brush, assisted by his sons, or sons-in-law, if he has any, and then plants his crop; usually corn for making more chicha. After that it has to take care of itself. He goes out occasionally to hunt, fish, or sometimes to bring a bunch of plantains. When the corn is nearly ripe, the boys have to watch it to scare off the parrots and pigs. If there are no boys in the family, then all hands usually go and occupy a little shed in, or on the edge of the cornfield. They feast on the green and ripening corn until it is too hard to boil, and then collect what has been left to ripen.

The labor of the women is to bring plantains and water, and to cook and wash. They are never required to do work in the plantation, unless

it be perhaps, to help gather and to help carry home the corn. All the sewing is done by the men, even of the little shirts or jackets worn by the women. In carrying loads, the women rival the men in power and endurance. It is nothing uncommon to see a woman, with a big load on her back, and her year old baby seated on top, with his little legs dangling over the front edge of the load. The little monkeys ride securely there through the bush and dodge the overhanging vines and branches as expertly as could be done by an old horseman. When working for each other the people use their own machetes and axes, as a matter of course; but when hired by a foreigner, they invariably expect to be furnished with tools by their employer.

Domestic industry is at the very lowest ebb. Manufactures can hardly be said to exist. The only articles made, beyond furniture, arms &c., are hammocks, net bags, cotton cloth, and pottery. All of these are coarse and inferior in quality. None of the skill exhibited by the Guatemalan Indians exists here. The hammocks are made of a coarse twine, derived from the leaves of a species of *agave*, and are loosely woven in a frame, with a needle. They are hardly long enough for an ordinary person to lie at length in them with comfort, and are used more for seats than for sleeping. They are swung between the posts of the house, near the door, and at a height of from a foot to a foot and a half from the floor. Everything is carried in net bags. They are made with a needle of bone and "meshed" like our fish nets. Some of them are very fine and they are of all sizes, from three inches to two feet deep. They are suspended by a string made of the same material, usually an inch wide and woven openly, in the same manner as the hammocks. The material of the finer and ordinary bags is the fibre of a species of aloe, or *agave*, much finer than that used for hammocks, and naturally nearly white. It is usually dyed of various colors to suit the fancy of the maker. The colors are obtained from several of the native plants and are very durable. A coarser kind is made of the same fibre as the hammocks. These are made with larger meshes, and are used to carry plantains, corn &c., from the field to the house.

The people of Tiribi procure all their bags from the Bri-bris, and I believe, their hammocks also. The Valientes, living beyond the Tiribis, in the adjoining parts of the District of Chiriqui, make similar bags, but much finer and more elaborately wrought. The colors in the Bri-bri nets are always arranged in simple bands, while the patterns of the Valiente nets are often complicated and exhibit considerable taste.

Belts, breech-cloths, cloths for wrapping the bones of the dead, and women's petticoats are woven of cotton. The cotton is raised with no care beyond planting a few seeds and allowing the plants to take care of themselves. They grow to the height of ten or twelve feet, and almost every house has a few in its vicinity. The yellow flowers, buds, and open bolls are seen all the year round, together on every tree. The women collect the ripe cotton, pick it from the seeds with their fingers and spin

it. The loom is a simple frame of four sticks, the two upright ones are planted in the ground ; the other two rudely tied to these. The warp is wrapped around the two horizontal bars and a simple contrivance of threads is arranged to open and reverse it. The thread for the woof wound on slender sticks is then passed through in the usual manner and driven tight by blows of a smooth stick. The process is exceedingly slow and tedious and I have never seen it performed except by the men. The belts are usually two to three inches wide and four or five feet long. Breech-cloths are about four feet long and a litle more then a foot wide. The cloths for the dead and the women's petticoats are wider and a trifle longer. Except the cloths for the dead, which are woven white and afterwards painted, most of this cotton work is ornamented with colors. Besides native vegetable dyes, the people of Bri-bri buy cotton dyed a dirty purple with the blood of the *murex*. This is procured from the people of Terraba on the Pacific. They also now occasionally buy colored threads of foreign production, especially a rich bluish purple, of which they are particularly fond. All of this weaving is with very coarse thread, nearly as thick as the finer twines used by shopkeepers in the United States for tying small packages. The cloth is consequently coarse in texture and rough in appearance, but closely woven and soft to the feel. It makes excellent towels, though rather heavy for that purpose. The largest piece of work of this kind I ever saw, was a blanket large enough to cover a good sized double bed. It was in possession of an old woman who wanted to sell it to me for a cow, and refused ten dollars cash.

The pottery now made is the coarsest and poorest I have ever seen. None of the finely made and elaborately ornamented vessels found in the *huacas* or graves are made at present. The use, for half a century or more, of foreign cast-iron pots and kettles has restricted this industry, and possibly helped to injure the character of the work. But two or three vessels taken by me from Tiribi graves, certainly not less than fifty or sixty years old, are in no respect superior to those made at the present day. Native earthenware is now only used for receptacles for chicha. The jars are large--say from ten to twenty gallons capacity. The form is very simple, the workmanship is rough, the clay is coarse and badly mixed, the burning is almost always imperfect, and they are always without the slightest attempt at ornament. The jars are moulded by hand, the clay being added spirally, and moulded by the fingers and trimmed with a smooth stick, in exactly the same manner as I have seen done by the negro women in Santo Domingo. After a certain amount of drying, they are burnt in the open air, in a fire of sticks heaped over them. Each jar is burnt separately.

Although not given to unnecessary exertion, these people travel occasionally from house to house, and even make journeys to Terraba and Limon. The laziest will gladly walk for two days to a dance. They also occasionally go off into the less frequented regious to collect sarsaparilla, with which to buy whatever of foreign manufacture they may want, like

axes, machetes, cotton cloth, &c. They never travel alone; always two or more going in company. This is a very prudent measure, since accidents are liable to happen, like snake-bites, or a bad fall, and a person alone and disabled in these wilds, would be more than apt to die before he would be discovered. The preparations for a trip into the forest are simple, but require time. If there are no plantains to be found in the neighborhood to which they are going, a large supply is collected. They are skinned, boiled, and dried hard in the smoke of a slow fire. This is to diminish the weight. A sufficient supply of corn is ground and made into a paste, either with or without the admixture of ripe plantain, for chicha. This is done up in bundles of about a gallon and a half in bulk, carefully wrapped in large leaves and tied with strips, torn from the footstalk of the plantain leaf. At last, all being ready, every person loaded with all he or she can carry, they start out, the loads done up in as compact a bulk as possible and carried on the back, suspended from the forehead by a strip of *mastate*, or bark cloth. Each person also carries in the hand a staff, four or five feet long, made of some tough wood. For ordinary purposes, the entire trunk of certain slender palm trees is used. This makes a stick about as thick as an ordinary civilized walking stick, but very strong, and sufficiently elastic to yield a little without breaking. The chiefs and a few other persons of consequence, like the priests, usually carry a stick of the red wood described above. This is neither so strong nor so light as the palm stick, but it is a privilege of rank, and is preferred in consequence. If the party is going on a trading trip—while the stronger members carry the load of sarsaparilla or rubber, still there are always some, either women or boys, who carry the inevitable bundles of chicha paste. Even when going from one house to another visiting, or to a dance, the chicha is not forgotten, unless the distance is so short that they are not liable to become thirsty on the road. On arriving at a house, the party enters without a word, and each person seats himself where most convenient, but as near the door as possible. The owner of the house, or in his absence, his wife or the next most responsible person approaches the new arrivals and salutes with, "You have come;" "I have come;" "Are you well?" "I am well, how are you?" "I am well." If a particular friend, or a person of consequence, he is invited to seat himself in a hammock. The people of less importance are allowed to take care of themselves. In a few minutes the women of the house approach with calabashes or vessels made of folded leaves full of chicha. If chocolate is to be had, it is prepared at once, and offered in place of chicha. This is a delicate attention, only shown to friends or persons of consideration. Common folks must be content with chicha. Whether chocolate or chica, it is served at least three times, at very short intervals, and at last, when you cannot swallow any more, the polite thing is to say to the person offering it, "drink it yourself," an advice usually followed, and which stops the supply. If the people are particularly inclined to be hospitable, and are fortunate enough to be well supplied, it is not uncommon for the

visitor to be overwhelmed with little presents of food. I have been presented within half an hour, in one house, with five calabashes of chocolate, at least half-a-dozen quarts of chicha, a dozen or more ears of green corn, and a dozen ripe bananas. The little boys, with whom I made friends, fared sumptuously, for it wasn't polite for me to refuse anything.

The houses of the Bri-bris are usually circular, from thirty to fifty feet in diameter, and about the same in height. They are composed of long poles, reaching from the ground to the apex. These rest on a ring of withes or vines, tied in bundles, eight or ten inches thick, and resting on a series of upright crotched posts, set in the ground in a circle about a third smaller than the outer circumference of the house. Above this ring, if the house is large, are one or two more, according to its size, not resting on posts, but tied to the sloping poles. The whole is thickly thatched with palm leaves, and finished at the apex by an old earthen jar, to stop the leaks. There is but one aperture to the house, and this is a large, squarely cut door, left on one side. Over the door there is sometimes made a little shed, to keep the rain out. The interior is always very dark. Sometimes, among the Bri-bris, instead of building the house in a circular form, it is elongated and has a ridge-pole, but the ends are rounded, and the door is in one of the ends.

Formerly the Cabecar houses were built in the same style; but now most of them are mere sheds, sloping to one side only and open at the ends and in front. The most pretentious house I saw in Cabecar was a roof sloping to both sides from a ridge pole to the ground, but open at both ends. The Tiribi houses are simply a roof raised on short posts, sloping both ways from the ridge but open all around below. Mr. Lyon told me that formerly the Tiribis as well as the Cabecars had round houses like the Bri-bris, but that the present style is due only to carelessness. The tribes are dwindling so rapidly that they seem to have lost heart even in so important a thing as building comfortable houses; and are content to put up with any make-shift that will shelter them from the weather. The Bri-bri houses are not only better constructed but are much better furnished than those of their neighbors. Beds are placed around the house in the space between the posts and the sloping sides. These are made by planting in the ground two sticks, forked at the upper ends; cross-sticks are laid on these, the other ends being lashed with vines to the sloping rafters. Over these two horizontal sticks are placed boards made of the outer shell of a species of palm; or wild cane is lashed close together. In front of the beds are slung hammocks, between the posts, or to the ends of horizontal sticks projecting a little beyond them. The fire is placed opposite the door near the back side of the house. It is kept up by placing close together, the ends of three large logs which are pushed up as they burn off. Over the fire is a barbacue or frame, sufficiently high to let people pass under it. On it is placed food to keep it out of the way of the dogs, pigs, chickens, and ants. The smoke of the fire is sufficient

protection from the latter. Back of the fire-place are ranged the chicha jars, two or three in number. Being round bottomed, they stand on the floor propped up by stones. Scattered around the house are stools or benches, rarely more than six inches high, each carved out of a solid block of wood. They generally have four feet, though occasionally a small, roughly made one is seen, with but two feet, and which is only kept in upright position when somebody is sitting on it. The pots and kettles about the fire are all of American cast iron, and vary in size from less than a quart to ten gallons capacity. Hanging from the barbacue over the smoke, is generally seen a cocoanut shell or a leaf bundle full of salt. It is kept here because it is the only place where it will remain dry. Suspended from the roof are baskets of from one to three cubic feet capacity. They are usually made of a peculiar, very hard, and very flexible vine. These are the trunks of the people, and in them are kept their clothing and all of their little personal treasures and ornaments. They are also used for storing corn or other seeds, like beans, the basket being then lined with leaves to prevent spilling. The women also use them for carrying water calabashes. These are either gourds or the shells of the fruit of the calabash tree, with a small round hole cut in one end. One other use of the baskets is to carry loads when the net bags are scarce. These nets are also often suspended about the house in the same manner as the baskets. Axes, always of the make of Collins, of Connecticut, and long machetes, either of this or of some inferior make, are to be found in every house. Collins' hardware has gained a permanent reputation among these people, who will give twice as much for a leather handled machete of this brand, as for any other kind. Of other tools, the most noteworthy is a heavy stick sharpened to a chisel edge at one end and beveled on one side. This is used for making holes in planting corn or plantain sprouts, and the edge is used to beat down high grass. It works almost as effectually as a scythe. Hooked sticks for lifting the iron kettles, others cut with short radiating branches at the end, like a five or six pointed star, for stirring chocolate, and paddles for stirring food are always found near the fire. Calabashes and gourds with small holes cut in one end for water bottles, and other calabashes cut in half for drinking cups, are also found in every house. Food usually, and even drink sometimes, are served in leaves, called in Spanish "platanillo," smaller and tougher, but otherwise resembling those of the plantain. These are dexterously folded so as to hold a quart or more of fluid without spilling.

Of arms, besides the inevitable machete and very good double-barreled guns, they possess bows made of a very tough kind of palm wood. They are straight and usually about five feet long. The string is made of the finer kind of *agave* fibre. The arrows are of three kinds. All have a butt two and a half to three feet long, made from the light flower stalk of the wild cane. This is a mass of pith, with a thin hard shell on the outside, giving the requisite stiffness. They are not feathered. The

front end, from two to even four feet long, is made of the same wood as the bow. For fish this is sharpened to a point and is barbed on one, two, or even three edges, or is made round. For quadrupeds, the wood is shorter, not barbed, and is tipped with a lance-like head made by laboriously grinding down an old knife blade to the requisite form. For small birds, the head ends in a broad round button, flat on the face. The Tiribis use also a little arrow, ending in a slightly open bunch of small reeds. These are for killing a fish, common in the Tilorio. never more than five or six inches long, and which rests attached to rocks by a sucking surface. The fish is so small that several points are necessary to the arrow, so that if one does not strike another may. No poison is used on the arrows, and, in fact the people seem to know of none. In their quarrels, a stick is used over six feet long, nearly an inch thick and about two inches wide, and made of the same wood as the bows, arrows, and planting-sticks. It is very heavy and is grasped by the fingers and thumbs of both hands in such a manner that they are guarded from a blow. They guard and strike an "over-blow" always holding by both hands. They are going out of use now that the people have discovered the easier, but more dangerous process of litigation. Cracked heads and broken arms give way to damages. For killing small birds the blow-gun is used. This is a tube seven or eight feet long, made by punching and burning the pith out from the heart of a palm trunk, nearly two inches thick. They are made very straight and true inside, and are provided with a double sight on top, made of two glass beads placed half an inch apart: when finished they are covered with some resin or a species of pitch to keep them from cracking or warping. The missiles are clay balls. These, previously prepared are carried in a little net, with them there are two bone implements. One, simply a straight heavy piece of bone used to drive a ball out of the tube by its weight, in case of sticking. The other is similar in appearance, but the end is worked into a round pit with sharp edges, for trimming the balls to the proper size and shape. During the war between the Bri-bris and Tiribis, at the beginning of this century, the principal arm used was an iron-headed lance fastened to a shaft barely four feet long. For defense, round shields were carried on the arm, made of the thickest part of the hide of the tapir. I was fortunate enough to secure specimens of both, together with nearly all the other implements, &c., described in the present paper. They are all in the Smithsonian Museum.

All people have some kind of music which doubtless gives pleasure to them, although to our unappreciative ears it may sound rude and disagreeable. The Marimba, an African instrument, found all over semi-civilized Central America, is unknown here. I cannot understand the surprise of an eminent African traveler, who writes wonderingly of the coincidence, of finding this instrument in use in Africa and among the Indians of Central America. It was introduced with the African slaves and has been retained among their descendants and neighbors. The

savage Indians do not possess it. The drum is their greatest favorite. It is from twenty inches to two feet long, cylindrical for half its length, with a diameter of six or seven inches; it then tapers convexly to near the other end and then widens out a little. The pattern is always the same, and the size varies but a few inches. The larger end is tightly covered with the skin from the belly of the iguana lizard. It is glued on by fresh blood, being held in place with string until dry. A cord tied around each end suspends it loosely from the left shoulder, and it is held under the left arm, being beaten with the tips of the fingers of the right hand. It is used principally to accompany and keep time to singing and is an indispensable part of every feast or gathering of whatever kind. To accompany the invigorating music of the drum and help the din, an armadillo skin is sometimes used. This is scraped over the rings with a large hard bean-like seed. It at least helps to add to the noise, if it does not contribute melody. A little flute, about as musical as a penny whistle, is sometimes added to the concert, though it seems rather to be looked upon as a toy. These flutes are made of a bone of some bird, perhaps a pelican. The bone has half-a-dozen holes drilled in it, and the end is plugged with wax, so as to direct the air to the larger aperture near the end. I bought one from a Tiribi made of a deer's bone. The priests use in their songs a rattle, made of a small pear-shaped tree calabash, lashed to a bone at the small end. This contains a few seeds of the "shot plant," or Canna. It is held upright and solemnly shaken in time with the song until the end of the stanza, when, as a signal for the chorus to strike in, it is given a dexterous twirl, throwing the seeds rapidly around inside. On very solemn occasions a curious box is also used. It is about eight inches long by four square on the end. It is carved out hollow, with a long tongue on one face, isolated by a U-shaped slit. A heavy handle is attached to one end, also carved out of the same block. When used, it is simply struck on the above-mentioned tongue with a bone or piece of hard stick. This is only used on the death of a chief. There is but one in the tribe, and no bribe that I could offer sufficed to buy it.

Fashions in dress change even among savages, at least as civilization approaches. Formerly the dress of the men consisted only of a breech-cloth. It was made of *mastate*, or bark cloth, about a foot wide and seven or eight feet long, tapering at one end. The cloth is made by taking the inner bark of either the India rubber or another tree and beating it with a roughened stick over a log. This loosens the fibre, and renders it soft and flexible. It is then carefully washed until all the gummy matter is washed out. After drying, it is rubbed a little and becomes soft and smooth to the feel. To apply the breech-cloth, the wide end is held against the belly, the remainder being passed between the legs; it is then wound around the waist and the point tucked in; the broad end then falls over in front, for about a foot long, like an apron. When cotton cloth is used, it is simply caught up in front and behind under a cotton belt, with a similar apron in front. Sometimes, for warmth, a shirt of

mastate was worn ; simply a strip with a hole in the middle for the head, and tied under each arm with a piece of string. Now many of the men have discarded the breech-cloth, and wear cotton shirts and pantaloons, buying the stuff from the traders and sewing them themselves. Others, not so far advanced, wear a shirt and a breech-cloth. Formerly the hair was worn as long as it would grow, sometimes rolled up and tied behind in a knot. Some of the conservatives still stick to the old style and follow this custom yet; others of the men wear their hair in two plaits, but the majority cut it to a moderate length, and either confine it by a bright-colored handkerchief tied round the head in a roll, or wear a hat.

The dress of the women originally consisted of a simple petticoat (*b ina*) of mastate. Very few now use this material, preferring the softer cotton cloth of the traders. The favorite color is a dark indigo-blue, with figures five or six inches across, in white. The *bana* is a simple strip of cloth wrapped round the hips, with the ends overlapping about six inches in front. It is suspended at the waist by a belt, and reaches more or less to the knees. When on a journey in rainy or muddy weather, I have seen a simple substitute. It was made of a couple of plantain leaves, stripped to a coarse fringe and wound round the waist by the midribs. With nothing above nor below it, it is the nearest approach to a fig leaf one can imagine. Only of late have the women begun to wear anything above the waist, and even now it is considered hardly necessary. Some of the women wear a sort of loose little jacket, or chemise, very low in the neck and short in the sleeves, that barely reaches the waist and only partially conceals the bosom. I have frequently seen a woman, in the habit of wearing one of these, either take it off entirely, or fan herself with it, if warm, in the presence of a number of men, and evidently innocent of improper intentions, and unaware that she was doing anything remarkable. With this scanty dress, I must do these people the justice of saying that they are remarkably modest, both men and women. In a year and a half of life in their country, traveling constantly with a body of them, bathing, fording rivers, living in their houses, and seeing more than strangers generally do of the intimate domestic life of the people they are among, I can only recall a single instance of carelessness, and not one of a wanton exposure of those parts of the person, that their ideas of modesty required to be kept covered.

The dress just described is that of the Bri-bris and Cabecars. The Tiribi men, where they do not wear pantaloons, always use the native cotton breech-cloth, never the mastate. The women wear a long strip of cotton cloth, made with a hole in the middle, like a poncho, and reaching before and behind, nearly to the ground. It is gathered up at the waist by a belt, and the edges are caused to overlap at the same time, so that the whole person is securely covered. I was also told that under this they wear a species of breech-cloth or drawers. They are much more retiring in their manner than their Bri-bri sisters ; never speak

to a stranger except when spoken to, and then reply in as few words as possible and with apparent bashfulness.

For ornaments, all wear necklaces. The favorite ones are made of teeth, of which those of the tiger are most highly prized. Only the canine teeth are used. Small strings are sometimes made of monkey, coon, or other teeth, but are not much thought of. I have seen one of these made of five strings of tiger teeth, gradually diminishing in size, and covering the entire breast of the wearer. The women rarely, almost never, wear these. If they wear teeth, they are of some very small animal. In place of them, they use great quantities of glass beads. I have seen fully three pounds of beads around the neck of one old woman, and she was the envy of all her friends and neighbors. Even little girls are often so loaded down that the weight must be irksome to them. Money is often worn by the women. On one occasion I paid a man six dollars, all in Costa Rican quarters, for his month's work. After a few days I went to his house and saw the entire sum strung on his wife's neck. Shells are also sometimes, though rarely used. The men sometimes carry, suspended from the necklace, the shell of a small species of *murex*, with the varices ground off and a hole drilled in it to make a whistle. These are bought in Terraba, and are highly prized.

The men sometimes wear head dresses made of feathers. The most highly prized are the white downy feathers from under the tail of the large eagle. Others are made from chicken feathers, or are worked in rows of blue, red, black, yellow, &c., from the plumage of small birds. I have seen one head-dress made of the long hair from the tail of the great ant-eater, in the place of feathers. The feathers are secured vertically to a tape and extend laterally so as to reach from temple to temple, curling over forward at the top, the tape being tied behind, so as to keep the hair in place.

Painting is somewhat in vogue, to assist in the adornment of the person, but is not confined to either sex. The commonest manner is to color each cheek with a square or parallelogram, about an inch across, either solid or made up of bars. This is done with the dark reddish-brown sap of a certain vine, and the pattern resists wear and tear, and water for a week or more. Anatto is also used, but more rarely, and is applied in bars or stripes to the face, according to the skill or taste of the artist. Besides, a hideous indigo-blue stain from a fruit, is sometimes smeared on the face or body, but even savage taste does not seem to approve of this, since it is very unusual.

Formerly the Tiribis tattooed small patterns on their faces or arms; but the younger people have not kept up the custom, and the Bri-bris and Cabecars say they never did it. The chiefs on great occasions wear gold ornaments, similar to those now found in the *Huacas*, or graves of Chiriqui. Whether these have been recovered from some of these graves, or whether they have been handed down from time immemorial is not known. There are but four or five in the tribe, and two of these belong

to the reigning chief. The others were formerly also property of the chiefs, but are said to have been given as rewards of merit to the most successful leaders in the Tiribi war. The two belonging to the chief, as well as one belonging to the descendants of one of those warriors, all represent birds. The people call them eagles. The largest is between three and four inches across; the smaller of the chief's two, is double-headed. In connection with these "eagles" another royal emblem might be mentioned. It is a staff of hard black palm wood, over four feet long. The top is carved in the shape of an animal, not unlike a bear sitting on his haunches. But there are no bears in this country, and it must have been intended for some other animal. Below this figure, the stick is square, and is carved out into four pillars several inches long, with spaces between them. In the interior, between them, is a cavity in which a loose piece of the same wood can be shaken about. It was evidently left there in the carving, after the fashion of the Chinese. Below this, the stick is plain. I tried every means in my power to obtain this, but could not buy it.

Games of chance or of skill are equally unknown, and even when brought into contact with civilization, they do not seem to take kindly to gambling. In fact, they have so little to win or lose, and that little is so easily obtained, that the inducement does not exist.

Their food is simple in material and there is but little variation in the manner of preparation. Of meats, besides chickens, they have beef and pork, which are however rarely used except at feasts. They know nothing of salting meat for future use and can only consume one of these animals when a large number is together. Besides the scarcity of beef is so great that probably no Indian possesses more than one or two animals at a time. Wild meat, like peccary, red monkey, (the other species are rarely eaten,) tapir, tiger, even otter, armadillo, and some other small animals are occasionally shot. In this case, all of the meat that is not eaten at once is dried as hard as a bone, and perfectly black, in the smoke of a slow fire. Larger species of birds like curassow are also treated in the same way. It is an interesting fact, universally attested, that the bones of this bird are absolutely poisonous to dogs, while the meat, though tough, is not unpalatable and is perfectly innoxious to man. After a meal it is the never-failing custom to gather all the bones carefully, and either burn them or place them out of reach of the dogs. I do not know whether the flesh would be equally dangerous, though I doubt if it was ever wasted on a dog. This property is said to be due to some fruit or seed they eat. Of vegetable food, plaintains are the staple. In times of scarcity, bananas take their place, besides being eaten raw when ripe. The Indians also occasionally eat a raw ripe plantain, although they are coarse and the flavor is inferior. The methods of preparation are, roasted green, when they make a poor substitute for bread; roasted ripe, when they are eaten with chocolate, with the idea of sweetening it. They are also boiled green, with meat, with green corn, or even alone. Ripe plan-

tains boiled and mashed, are mixed in equal quantities of corn-meal paste to make chicha, or to bake in cakes. They are also, when ripe, boiled, mashed into a paste, and mixed with water into a gruel. This is drank under the name of *mish'-la.* Maize is raised in considerable quantities, and this really involves four-fifths of all their agricultural labor. The corn is of a variety of colors ; white, yellow, red, purple, blue, and almost perfectly black. Sometimes the ear, rarely more than six or seven inches long, is of a uniform color, but more generally the grains are of two or more colors. It is boiled green and eaten from the cob, and is thus considered a great delicacy. It is, when ripe, ground for all other purposes. The process of grinding is rude and simple in the extreme. If possible, a stone, three feet long and two wide, with a flat upper surface, is procured. In default of this, a broad slab of wood is used. For this purpose, a piece cut from one of the plank-like buttresses of the Ceiba tree is procured, and one side dressed smooth. The remainder of this primitive mill, is a stone, about a foot or fourteen inches long, a few inches less in width and three or four inches thick. One side must be regularly curved. The corn, soaked over night to soften it, is placed on the flat surface and the stone last mentioned is rocked on its edge, from side to side. This is always done by the women. When the corn is sufficiently ground, the paste is put into an iron pot and boiled to mush. If it is intended to make cakes, a part of the raw paste is mixed with an equal quantity of boiled ripe plantain paste, to sweeten it. It is then rolled in plantain leaf and baked in the ashes. When the paste is boiled, sometimes a part of it is separated, thinned to the consistency of gruel, and drunk hot. If it is intended to make chicha for the road, the thick mush is at once mixed with an equal part of ripe plantain paste as before, and tied up in leaves. This will keep sweet for two or three days, but gradually fermentation takes place, and at a week old, it has a not unpleasant sweetish acid taste. When ready for drinking, it is dissolved in cold water to a thin gruel. The taste for it is easily acquired, and I admit, I became very fond of it. It certainly does possess intoxicating properties, but I cannot conceive how any civilized stomach could accommodate a sufficient quantity to produce exhilaration. Still I have seen Indians very happy from its effects. But since I desire these notes to be believed, I do not dare to state the quantity I have seen one of these fellows drink. Were only half the truth told, it would appear incredible. The method of preparing the chicha for use in the house is slightly different. The paste is thinned at once, while yet hot. The plantain paste, also thinned, is poured into the earthen jar with it, and sufficient water is added to bring it to the proper thinness for drinking. To produce rapid fermentation another process is yet necessary, which I saw once at Dipuk on the Uren. A young girl (young girls only, with sound teeth perform this operation,) having previously rinsed her mouth with a little water, sat down on a low stool, with a pile of tender raw corn beside her, and a big calabash in her lap. She chewed, or rather bit the grains from the

ear and ejected them from her mouth into the calabash. The rapidity of the process was marvelous. She seemed to shave all the grains from an entire ear almost without stopping. There did not to seem be much chewing done, but of course the object was to obtain the saliva secreted during the operation. As fast as her calabash was full she emptied it into the jar of chicha, and proceeded to refill it I lay in my hammock fully half an hour watching her until she had finished. The next day that chicha was drank and pronounced excellent. I never tried this kind. Such is the force of prejudice. I learned early to prefer doing my own eating.

Beans are also used to some extent, but the quantity planted is generally small, and the people soon have to return to their regular plantains and chicha. I do not think I ever saw half a bushel of beans together in one house. They are large, dark, and generally mottled. They never become very hard, and are of a very good flavor. Small quantities of sugar cane, of a very excellent quality, are raised, but it is only for the purpose of chewing. They never attempt to make sugar or syrup, although some of the foreigners in their country as well as the negroes on the coast make the latter, and the Indians are perfectly familiar with the process. Of the foreigners in the country, perhaps a dozen in all, sambos or mulattoes, with the exception of Mr. Lyon, all raise rice as one of their most important food-staples. The Indians are fond of it, frequently buy it, but never attempt to cultivate it. Of the less important items, they have the fruit of a species of palm called *du-ko'* (*pejiballe* of the Spaniards). This is a small pear-shaped fruit, growing in great clusters ; it has a thin skin on the outside, and a small round seed in the centre. It may be compared to a diminutive cocoanut, the edible portion corresponding with the fibrous husk of that nut. The seed corresponding with the cocoanut proper, is solid and very hard, but has a pleasant flavor. The fruit is very easily raised, requires no care beyond the first planting, and a little weeding for the first year or two, and yet, except at Sarwe, it is very scarce. It is from the wood of this tree that the bows, the arrow tips, the planting and fighting-sticks, &c., are made. Another species of palm furnishes a food, agreeable to the taste, an excellent salad when properly dressed, a perfect substitute for cabbage when cooked, but withal, as my party discovered on one hard journey we made, not very nutritious. It is the bud of tender, half-formed leaves at the top, and can only be obtained by cutting down the tree. It is similar to the deservedly famous palm cabbage of the West Indies, and differs principally in being only about half as large. We found, after living on it almost alone, for nearly a week, that it was good principally for deceiving one's self into starving on a full stomach. *Kiliti*, or "greens" is a favorite dish, probably not much more nutritious than the last. It is made from various tender leaves, put into a pot with little or no water, and gradually steamed into a paste with their own juice. This is eaten with salt when they have it ; otherwise, without.

Cacao is in great demand. The delicious sub-acid pulp is first sucked from the beans, which are roasted and ground on the chicha board, or stone into a coarse paste. It is the greatest luxury they possess. And still, I have never seen a young cacao tree belonging to an Indian. They depend for their supply on the old trees, planted by past generations. I have known an Indian make a two days' journey to collect a little cacao, when less labor would plant him fifty trees near his house.

Fishing is rarely performed with hook and line. They have two methods. One is to shoot the fish from a canoe (all the canoes belong to foreigners), or from the shore, or a rock. They use very long arrows, described previously, and are quite expert. Another method is to select a channel of the river beside an island. A frame-work is built at each end, of sticks and cane, which extend completely across the stream. When everything is ready, the people stationed at the upper end rapidly cover the frame-work with the leaves of the cane, so as to stop the water running through. Those at the lower frame, also spread on cane leaves, but thinner, only so as to keep the fish from passing through. Both parties must work at the same time, and as rapidly as possible, because as soon as the fish find the level of the water lowering they attempt to escape, and I was told that it has sometimes happened that every fish has gotten away before the dams were finished. In the course of a few hours the water is so low that the fish congregate in the deeper pools and are shot with arrows, or even taken out by hand.

The only divisions of time known are the natural astronomical ones: the day, the lunar month, and the year. A glance at the vocabulary will show that special words are used for day in the abstract as distinguished from night, and for to-day, to-morrow, day after to-morrow, &c., and for yesterday, &c. The month is called by the same name as the moon, "*si*." The year is counted from dry season to dry season, and is recognized by the ripening of the flower-stalks of the wild cane, on which they depend for arrow-shafts. It is called *da-was'* from this connection.

The local diseases of the country are fevers, acquired by going to the coast; or by the hill people, by going down to the low lands. They sometimes seem to become epidemic, due to an unusually wet season, or to the continuance of the rains throughout what should be a dry season. The summer of 1874 was particularly fatal in this respect. Rheumatism is common, especially with the older men. It is brought on by much exposure to rain, and by wading rivers when heated, on journeys. But the commonest infirmities are indolent ulcers, usually on the legs. They originate from any little scratch or bruise, and are the result of the low vital state of the system, due to a bulky but innutritious diet. A wound which, in a person in good health, would heal in a week, may result with one of these people in a sore lasting years, and perhaps at times involving an area twice as large as the hand.

Of remedies, they may be safely said to have none. They are learning

to apply to the traders for medicines for fever. All go to Mr. Lyon in case of snake-bite, and when taken in time, he says he has never failed to cure a case with either ammonia or iodine, as seemed to be indicated. It may be interesting to note that after obtaining no relief with one of these medicines, he has given the other, and with immediate good results. He gives the iodine in the form of alcoholic tincture in 10 to 15-drop doses, every 10 to 15 minutes. Some of them seem to believe in the incantations of the *Awas* or doctors, but foreign medicines are gradually gaining ground over sorcery. For rheumatic pains, headaches, &c., there are two remedies used. The simplest is counter-irritation by whipping with nettle leaves. The other is bleeding. The lancet is made usually from the tongue of a jew's-harp, broken off at the angle and sharpened to a point. This is set at right angles in a little stick for a handle, and is used by holding it over the affected part and striking it briskly with a finger. They never regularly open a vein and draw off a quantity of blood, but every stroke makes a separate puncture, from which only a few drops exude. At Borubeta I saw a man bled to relieve the aching of fatigue in his arms. He had been scraping *agave* leaves, to extract the fibre for hammocks. He had at least fifty punctures made over his two arms.

The natural products of the country are principally sarsaparilla root and india rubber. The sarsaparilla vine is green, angular, and covered with thorns. It grows very long and climbs over bushes and even trees in the more open parts of the forest. At short distances it is jointed, and if it touches the ground every joint sends out a new set of roots. The leaves are large and acuminately oval and have three longitudinal ribs, the midrib and two parallel ones, half way between the middle and the edge. The fruit is round and grows in a cluster something like grapes. The vine has a tap-root, and besides sends out a large number of horizontal roots near the surface of the ground, and from six to ten feet long. The sarsaparilla hunter first clears away carefully all the bushes and undergrowth with his machete. He then, with a hooked stick, digs into the ground at the base of the vine until he loosens the earth and finds where the best roots are. The tap-root is never disturbed, and it is customary to dig up only half the roots at a time, to avoid killing the vine. Having selected those that look most promising, he places his hand under one or two and gently lifting them, follows their course with his hooked stick, loosening the soil and lifting them out, following them to their ends. They are then cut off, the dirt carefully replaced around the vine, and the roots laid in the sun, or hung up to dry. A vine yields generally from four to nine pounds of green roots. When dry they are tied into cylindrical rolls a foot long and four or five inches thick, weighing about a pound.

India rubber is obtained by scoring the bark of the trees obliquely. Several cuts are placed one above another and in pairs converging downwards; the sap being directed in its flow by a leaf placed at the bottom, which serves as a spout, to direct it into the vessel placed to receive it.

When collected it looks like milk. It is caused to coagulate and turn black by the juice of a species of convolvulus. It is generally made into cakes a little over a foot long, about eight inches wide and an inch thick.

It is with these two articles, and an occasional deer skin, that all the purchases are made from the traders. They buy various kinds of cotton cloth for clothing, colored handkerchiefs, needles, thread, machetes, axes, knives, iron kettles and pots, a few medicines, and powder, shot, and caps. Their intertribal trade is still more limited. The Bri-bris sell net-bags and hammocks to the Tiribis, and formerly made the large cotton blankets, already described, for sale in Terraba. They buy in Terraba cows and dogs, murex-shell whistles, murex-dyed cotton, and beads made by rubbing down a small species of shell of the genus *Conus*. Sometimes both the Bri-bris and Cabecars, but especially the latter, carry sarsaparilla or rubber a hard ten-days' journey to Matina, to exchange it for cacao, of which they might have enough and to spare for the mere trouble of planting it. But Indians are, almost without exception, a lazy, miserable, and unimprovable race.

It is perhaps advisable to state that the whole of the present memoir was written in Costa Rica, and it was not until my return to Philadelphia, that I encountered the elaborate compilation of Bancroft, on "the Native Races of the Pacific States." At the date of the present writing, but three volumes of the promised five have made their appearance. While I regret that the information in that work, on the present field is so meagre, and in some respects so different from my own observations, I have said nothing which I wish either to retract or modify. I state nothing but what I have seen and learned while living among the people whom I describe. At the same time I trust that I may not be accused of a spirit of antagonism, in pointing out some of the more serious errors in the work in question, and which, if not corrected, might seriously mislead future students.

Vol I. Chapter VII. p. 684, *et seq.* is devoted to "the wild tribes of Central America," and the Indians living below Lake Nicaragua, and the San Juan River are here designated as Isthmians; an appropriate name, since the family seems to cover all of Costa Rica and most, if not all of the State of Panama. But the map, facing p. 684 is utterly incorrect in so far, at least, as it professes to give the distribution of the Indians of Costa Rica.

The region of Talamanca described by me, as containing the three tribes of Cabecars, Bri-bris, and Tiribis, and known to the Spaniards under the generic term of Blancos, is here given up to the Valientes, who should be placed to the south and south-east of the Chiriqui lagoon; and the Ramas, who live in Nicaragua, back of the Mosquito coast. The central plateau, in which are situated the cities and towns of Atenas, San Ramon, Alajuela, Heredia, San José, Cartago, &c., in short, that occupied by practically the entire Hispano-American population of Costa Rica, is here given to the Blancos, and on the shores of the Gulf of

Nicoya, where at present no Indians live, are placed Orotiñans and Guetares. Further, no tribes are placed in South-western Costa Rica, where the semi-civilized Terrabas and Brunkas live ; but on p. 748, the author states that "dwelling in the western part of the state are the Terrabas and Changuenas, fierce and barbarous nations, at constant enmity with their neighbors." Now the Terrabas, as well as their neighbors the Brunkas, or as the Spaniards call them, the Borucas, live in one or two little villages, and are under the complete control of missionary priests, both ecclesiastically and municipally, and are rapidly losing their language, as they have their savage customs, and are approaching the civilized condition of the villages of Pacaca, Coa, Quiricot, &c., in Costa Rica, where the Indians speak only Spanish, and have even lost the traditions of their former state. Again, the Changuinas formerly occupied the valley of the Changuina or Changina River, the main branch of the Tilorio, on the Atlantic slope, and are either entirely extinct, or only represented by a handful of individuals, swallowed up by the neighboring Tiribis on one side, and the Valientes on the other.

In the proper place I have noted what can be said of the Guatusos; there is nothing to add, until a responsible observer has the good fortune to penetrate their country, and survive to tell his tale.

On p. 793 of Vol. 3, is a very short vocabulary of "the language of the Talamancas," copied from the publication of Scherzer. This traveler did not visit Talamanca, but from internal evidence I believe the words to have been obtained from some of the half-civilized Cabecars of Tucuriqui or Orosi, little villages not far from Cartago. In evidence of its unreliability, I note two or three of the most glaring errors of the list.

"Man signa-kirinema. Woman signa-arágre."

Here *signa*, clearly a clerical error for *sigua*, means foreigner, and the word given for woman—*sigua crákur* means foreign woman. So, the prefix *sa* and *su* before the names of parts of the body is the personal pronoun—our. *Suhu* is *sa hu* "our house." "I *be-he*," is really *thou*, the error arising from the Indian answering *thou*, when he was asked, "how do you say I," the interlocutor doubtless pointing to himself. Fortunately the vocabulary is very short, but I am sure there are not more than three or four words in it that would be intelligible to a Costa Rican Indian.

CHAPTER II.

THE LANGUAGES OF SOUTHERN COSTA RICA.

SECTION I.—THE BRI-BRI LANGUAGE.

In the following notes, I have endeavored to embody such ideas and conclusions as I have arrived at while studying the language and compiling the vocabulary. From the difficulty of obtaining information from ignorant people, and from my own, by no means perfect knowledge of the language, possibly errors may have crept in, but while I do not think any important ones will be found, I do not venture to claim infallible accuracy. For a year I labored to find some rule for conjugation, and was obliged, as it were, to educate my informers up to the point of being able to give me information about a subject they had never thought of, and could see no use for. Not content to accept their statements categorically, I watched carefully the use of the verbs in their inflexions, and by dint of cross-questioning a number of people, and rejecting everything that was contradictory, I think the few verbs I have selected are correctly given. I have had the advantage not only of a year and a half in the country, in daily contact with a fellow-countryman who spoke the language fluently, enabling me thereby to learn it; but for two months, in the meantime, while absent, I had several intelligent Indians with me who understood Spanish, and finally, after returning to civilization, I had with me for eight months a native, with whom I talked habitually in his own language, and from whom I obtained many corrections of the errors that a stranger must necessarily make. This boy became an apt teacher and voluntarily set me right whenever he heard me use an incorrect expression.

Counting the few abstract words which have doubtless escaped me, and all the specific names of animals and plants, and many of the latter are made up of an adjective, or the name of some plant, combined with *wak* (tribe), I do not think the language can contain two thousand words, and perhaps not fifteen hundred. In preparing the vocabulary I have rejected most of these specific names, because there is no corresponding English word, and a complete natural history collection, carefully studied by competent students, would be required, so as to obtain an equivalent. Even then it would have been useless, because the names vary locally as much as similar words do in English.

In compound words, I have in most cases pointed out the roots, and separated the component parts by a + sign. Although so much detail may have been unnecessary, the study was interesting to myself, and some of the curious results may also interest others.

There can be no doubt but that this and its allied dialects, like all unwritten languages, are undergoing great changes. The language spoken in Terraba was formerly, and probably not long ago, the same as that of Tiribi. There are marked differences between the Cabecar of Coen and that of the Estrella or North River, and even local differences in the use of *r*, *l*, and *d*, can be observed between the half of the Bri-bri

tribe living on the Uren, and the others scattered over the rest of the country. In different districts "a little," *wi-ri-wi'-ri* is also pronounced *bi-ri-bi'-ri* and *wi-di-wi'-di*, and many other words especially those with *r* or *d* before a vowel, vary fully as much. As has been justly observed by Max Müller, laziness often helps this. The present name for rain *kon'-ni* for instance, is clearly derived from *koñg'-li*. In fact the proof exists in the form of the word for dust *koñg'-mo-li*. But *kon'-ni* is easier to pronounce than *koñg'-li*, and has taken its place.

It would be an interesting study to trace out the ideas which have influenced the formation of compound words. In Bri-bri, a hill is *koñg'-bĕ-ta*, the point of the country; in Cabecar it is *koñg-tsu'*, the breast of the country, from *tsu*, a woman's breast. Again in Bri-bri a sharp knife is said to be *a-ka'-ta*, toothed (that it may bite, or cut), the beak of a bird is called its tooth; and the same root (*kwo*) is used for a finger-nail, a fish-scale, a bird's feathers, the bark of a tree, or the rind of a fruit.

Some few words are used in such varied connections that they warrant special notice. Among these are *wo*, *koñg*, *ĭ-tu*, *kin*, &c. *Koñg* is a part of nearly all words relating to the earth, the sky, the atmosphere, in short the general surroundings. It means the country, the day, the weather. In composition it forms part of the word for a hill, valley, &c. *Wo* means originally round, either circular or globular. It is also applied to almost all masses or lumps; it further forms a component of words having a reference to entirety or completeness; thus alone, it means the human face, in compounds it forms a part of the names of the sun and moon, of many parts of the human body, of a drop of water, of a knot, of fruits, seeds, &c; and of verbs, such as to make, to close, to open, to extinguish, to tie, &c.; *ĭ-tu'* means originally to chop, but is applied to shooting, striking with intention of wounding (in contradistinction to *i-pu'* to whip). It also forms part of the verbs to shut, to extinguish, to lie (or throw one's self) down, and, in the latter sense is also used for to pour (to *throw* out of a vessel). *Kin* means a region, or district, and is always used in connection with some qualifying word; thus *Lari-kin*, the country or region of Lari; *dĕ-je'-kin* the salt region or sea; *tsong'-kin* the sand region, or beach; but *nyo-ro'-kin* means in or on the road, and *bĕ-ta'-kin* on top (of a hill or mountain). *Ki-cha'* means originally a string; derivatively a vine to tie with is *tsa' ki-cha*, or a string vine. Veins and tendons are called by the same word on account of their resemblance to strings, while the joints of the limbs are called *ki-cha'-wo* or the lump of strings. *Pa* and *pe*, mean people; the former combined with the 3d person, singular, personal pronoun *ye*, makes *ye-pa*, the 3d person, plural. It is also used combined with *wak*, tribe; thus, *Lari-wak*, means the people of Lari; *sa wak-i-pa*, our people; in this case used probably as much for clearness as anything else, since *tsa wak*, ("*vine-tribe*") means ants! *Ha wak-i-pa*, your people. *Pe*, used alone means somebody; whose is it? "*pe cha*;" "somebody's," *cha* being the sign of possession.

There are several words which change their form, or which are even substituted by others, according to the sense or connection; thus *u'-te-kin*, sometimes pronounced *hu'-te-kin*, means out or outside of the house or of anything else in all ordinary cases; but for a person to go out of the house is not *mia u'-te-kin* or *mia hu'-te-kin*, but *mia hu pa'-gl*. This *pa'-gl* is used in no other connection; and the sound occurs nowhere else in the language except as *pagl-chi-ka* (sugar) and *pagl*, the numeral eight, with either of which, it is obviously not related. But the numerals illustrate this most markedly. For instance three is *m-nyat*, and as such it is used in counting all *things*; three houses, *hu m-nyat*; but three men are *pe m-nyal* and three days are *koñ m-nyar*. *Bit*, how many, becomes *bil*, how many persons, &c. Old, fat, to grow, pregnant, &c., change in a similar manner when applied to animate and inanimate, or to human and lower objects.

It is remarkable that in a language otherwise so poor, at times it should go to the other extreme. In civilized languages, notably in Spanish, there is a great variety of words to express the shades of colors of animals, particularly the horse. These words, originally adjectives, are often used as nouns. But in Bri-bri we have eight nouns to distinguish pigs, six of which are for color; viz.:

white,	*mu-lush'*.
black,	*do-losh'*.
gray,	*bish'*.
red,	*mash* (*a* as in far).
half-white, half-black.	*bĭ-tsus'*.
black, with white face,	*kŭ-jos'*.
with throat appendages,	*bu-lish'*.
short-legged,	*na'-na* (Spanish *enana*, a dwarf).

These words are in every sense nouns only, and are just as correctly the names of the respective animals as the generic term "*coche*." Chickens and dogs have similar distinguishing names, but I have never been able to learn that horned cattle (*vaca*, whether bull or cow,) are so honored. Horses are comparatively unknown. The only representative of the race in the country being Mr. Lyon's old yellow mare, there has never arisen the necessity for the additional tax on their inventive powers. Words expressing physical qualities of matter are as abundant as in more civilized languages, and their use is as strictly limited. Hard, strong, or stiff, is *dĕ-re'-re*. Soft, like a cushion or fresh bread, is *b-jo'-b jo*, while soft like cloth it is *a-ni'-a-ni* or *a-ni'-ni-ĕ*. Weak or fragile, like a string, or a vessel, powerless like a weak person, or tender like meat, are *to'-to* or *to-toi'*. Elastic, like caoutchouc, is *ki-tsung'-ki-tsung*; when like a switch, it is *kras'-kras*. Plastic, like mud or putty, is *i-no'-i-no*. Pasty, like dough, is *i-tu-woo'*. When more fluid, like very wet mud, it is *a-bas'-a-bas*. Viscid, like syrup or honey, is *kŭ-nyo'-kŭ-nyo*; while very fluid, watery, is *di-se-ré-ri*.

Plantains, bananas, maize, and beans must have been in use by the Indians before the arrival of Europeans, since they have specific names for all of them, but all domestic animals have only the names that came with them.

I have found very few words that I can trace clearly to foreign sources. The names of introduced animals, mentioned above, articles of clothing, and foreign utensils make up almost the entire list. We have *ar'-roz*, Spanish arros'; *sombre'no*, Sp. sombrero; *zapato*, pure Spanish; *pana*, English pan, all hollow vessels of thin metal, of whatever form; *cuchara*, Spanish; *bi-wo*, English bead, *wo* native word for anything round; *tigera*, Spanish; *pussy*, English; *chi-chi*, Aztec *techichi*, the edible dog of Mexico (*fide* Belt), a word used all over Spanish America, and adopted by the Bri-bri and adjoining tribes in the Spanish form; *cachimba*, vulgar Spanish; *da-wa'*, probably corrupted from tabaco; *ko-no'*, corrupted from canoe; *vaca*, *caballo*, and *coche*, Spanish. *Alma*, a corpse, bears a suspicious resemblance to the Spanish *alma*, the soul. *Do-ko-ro'*, a chicken, seems to be derived from the crow of the cock; *i-e'-na*, is probably not the Spanish *llena*, with which it corresponds in meaning, but is derived from *e'-na*, finished. *Ese*, that, and *es-es* (= Spanish *eso es*) are probably derived from the Spanish.

The enumeration is decimal, and is simple in structure. Few pretend to count beyond ten, and in counting loose objects if the number is considerable, they are set apart in groups of ten; thus forty-six would be four tens and six. In speaking of numbers the fingers come into play. It is as common to see three, four, or more fingers held up, with the remark "so many" as to hear the numeral mentioned. Beyond ten, the toes are called into service, and the surplus over the ten toes is counted on the fingers, held downwards in this case. The word for five, *skang*, is clearly (*u-ra*) *ska*, the fingers. Beyond ten we have "ten more one," &c., but from twenty upwards I found so much confusion of ideas and contradiction that I strongly suspected my informers of politely trying to invent compounds to please me. By careful questioning, and still better, by watching conversations, I found that twenty is "ten two times," &c., after which the form of the "teens" is repeated; so that twenty-one is "ten two times more one," *d'bob but juk ki et*. There is no word for one hundred unless we use *d'bob d'bob juk*, which would be legitimate and intelligible, although I confess I never heard it used.

Wa, *ka*, *ke*, and *ta* added as suffixes are equivalent to the English *ed*. Thus *ĭ-da-wo'*, to die; *ĭ-da-wong'-wa*, dead; *lin'-a*, crazy; *ya lin'-a-ka*, he is crazed; *pat'ye*, to paint; *pat-yet'-ke*, painted; *su-tat'*, flat; *sut-tat'-ke*, flattened; *boi*, good; *boir'-ke*, healed; *bĕ-ta'*, a point; *bĕ-ta'-ta*, pointed, &c.

Kli used as suffix is equivalent to our *ish*; thus *boi*, good; *boi-kli*, goodish (*i. e.* pretty good or well); *tyng*, large; *tyng'-kli*, largish; *mat'-ke*, red; *mat'-kli*, reddish. *Ung* and *ong*, which in Terraba and Tiribi are almost the universal signs of the active verbs, are represented by the termination

ung in nearly a dozen Bri-bri verbs, where it has about the same value as English affix *ate*.

Articles and conjunctions do not exist in the language, the other parts of speech being however present.

Nouns have no inflections for gender, number, person, or case. If it is desired to express sex, the word male or female is used; thus my daughter is called *je la e-ra'-kur*, my woman child; a bull is *vaca we'-nyi* or male cow. The only exceptions to this rule are the few words referring to the human race, like man, woman, and some of the family relationships. Beyond this no distinctions of gender occur.

Number is always indicated by a numeral or by such words as much, many, &c. Two or three words occur that may be considered as apparent exceptions. *Di-cha'* means a bone; *di che'* is bones. *Di-ka'* is thorn and *di-ke'* is thorns, not two or three, but all the thorns on a tree, in a collective sense. *U-ra'-ska* (*u-ra* arm) is a finger, while *u-ra-shkwe'* (? fingers) is the hand. The coincidence in the termination of these isolated plurals, if they can be so called, is worthy of note.

Person is only indicated by the addition of a personal pronoun. The only semblance of inflection for case, is the addition of *cha*, the sign of possession, alike to nouns and pronouns; or of the prepositions, *wa*, *ta* (with), &c., as suffixes, making an ablative.

The personal pronouns are all monosyllables except *ye-pa* (they), a compound of *ye* (third per., sing.) and *pa* people. Although normally of one syllable, they are often used with the termination *re* (except *ye-pa*) for either emphasis or euphony; thus it is equally correct to say *je* or *je'-re*. *Me* (yourself) is used only in connection with a verb, like *me-sku*, move yourself; *me tu is*, lie (yourself) down. The sign of possession, as stated above, is added alike to the pronoun, or to the name or title of a person; *je-cha*, mine. *Ese* (that) is probably derived from the Spanish, and with *i* (literally *what*) does duty for the neuter. Where the nouns in a language are so simple, it is hardly to be expected that the adjectives and adverbs should suffer many changes. *Boi*, good or well, used either as an adjective or adverb, becomes *boi-na*, better, and a sort of superlative is formed by adding very; *boi chukli*. *Tyng*, large, is in an increased degree either *tyng chukli*, very large, or *tyng bru*; *bru* meaning also large but adding emphasis when the two words are combined. To *boi* and *tyng*, *kli* is added as a suffix to qualify the sense, like *ish* in English; *boi-kli*, goodish, pretty good, and *tyng-kli*, largish, or somewhat large.

The short *i* which begins most of the Bri-bri verbs, is not specially the sign of the infinitive, but is almost universally used where the verb is not preceded by another word, and is sometimes used even then for euphony.

There are four well-defined moods: the infinitive, the indicative, the subjunctive, and the imperative. The subjunctive is as simple as in English, being formed from the indicative by *mi-ka-re'* (if) placed at the beginning of the sentence.

Humboldt,* in speaking of the language of Venezuela, says: "The Chayma and Tamanoc verbs have an enormous complication of tenses," and adds that "this multiplicity characterizes the rudest American languages." It certainly does not apply to the Costa Rican family, which is equally remarkable for the simplicity of its inflections. The present tense does duty for the present participle, and the perfect for the perfect participle; besides which we have the past and but a single future. There is no variation for number or person.

The auxiliaries used are not constant. For the imperative, *ju* is sometimes prefixed, and *mia* is often the sign of the future. It is generally a prefix, but in *ĭ-haw-na*, to fall, it is added to the end of the word. *Etso* (from *etso-si*, to be,) is the sign of the present tense in *pat-yu*, to paint.

The following examples will give a better idea of the conjugations than a lengthy explanation. They were selected from a large number, and have been verified with as much care as the difficulties of the case would admit. I believe they may be safely trusted, inasmuch as they are words that I have heard in constant use for over two years, and not trusting to categorical information, have watched their habitual use in conversation. The first example, *ĭ-mi'-a*, is the most variable verb in the language. The forms given in each tense are usable interchangeably. It is equally correct to say, "*je mit-ka*," or, "*je mi-at'-ka*," I go. The past *re*, and *ra'-re*, are used everywhere except by a few people on the Coen River, where the more regular form, *mi-a'-na*, is used.

CONJUGATIONS.

To go.

Inf. ĭ-mi'-a.

Ind. Pres., { mi-at'-ka, / mit'-ka, } used interchangeably.

Past, { re, / ra're, } from the verb, *ra'-tski;* the forms ordinarily used.
mi-a'-na; used only on the Coen River.

Perf., mi-cho'.

Fut., { mi'-a, affirmative.
(ke) mi'-na, negative (*ke*, not.)

Imperative, ju. When in combination with an object expressed; *be* JU *i-tu*, "thou go shoot." This is the almost universal auxiliary sign of the imperative mood.

ju-shka, *ju*, as above; *shka* (*shku*), to walk.

mi'-shka, confined to the first person plural. It means, "let us go," or, "come," and can be used as an auxiliary to almost all the other verbs; *mi-shka du tu*, "let us go birds shoot."

* Trav., vol. i., p. 327, Eng. Ed.

To burn.

Inf.		ĭ-nyor′-ka.
Ind.	Pres.,	ĭ-nyor-ket′-ke.
	Past,	ĭ-nyor-no′-ka.
	Perf.,	ĭ-nyor-no′-wa.
	Fut.,	ĭ-nyor-wa′-ne-ka.

To cook.

Inf.		ĭ-lu′.
Ind.	Pres.,	ĭ-luk′.
	Past,	ĭ-li′-na.
	Perf.,	ĭ-let′-ke.
	Fut.,	ĭ-lu′.
Imper.		ĭ-luk′.

To speak.

Inf.		ĭ-šhtu′.
Ind.	Pres.,	ĭ-šhtuk′.
	Past,	ĭ-šhte′.
	Perf.,	ĭ-šhtet′-ke.
	Fut.,	ĭ-šhte′.
Imper.		ĭ-šhtuk′.

To walk.

Inf.		ĭ-shku′.
Ind.	Pres.,	ĭ-shkuk′.
	Past,	ĭ-shke′.
	Perf.,	ĭ-shket′-ke.
	Fut.,	ĭ-shku′.
Imper.		shku′-ta, walk to (come).
		ju′-shka, walk from (go).

To this verb we must add the following irregular forms: *shkat′-ke*, to walk ahead; its derivative, *it-kat′-ke*, has gone ahead, and *mi′-shka*, for which see the note to the first verb, *ĭ-mia*.

To shoot, to chop.

Inf.		ĭ-tu′.
Ind.	Pres.,	ĭ-tuk′.
	Past,	ĭ-te′-na.
	Perf.,	ĭ tet′-ke.
	Fut.,	(mia) ĭ-tu′.
Imper.		(ju) ĭ-tu′.

To paint.

Inf.		pat′-yu.
Ind.	Pres.,	(etso) pat-yuk′; (*etso*, to be).
	Past,	pat-ye′.
	Perf.,	pat-yet′-ke.
	Fut.,	pat-ye′-ke.
Imper.		pat-yuk′.

To eat.

Inf.		ĭ-kŭ-tu′.
Ind.	Pres.,	ĭ-kŭ-tet′-ke.
	Past,	ĭ-kŭ-te′.
	Perf.	ĭ-kŭ-te′-wa.
	Fut.,	ĭ-kŭ-te′.
Imper.		ĭ-kŭ-tuk′.

To start.

Inf.		ĭ-bĕ-te′
Ind.	Pres.,	ĭ-bĕ-te′.
	Past,	ĭ-bĕ-te′.
	Perf.,	ĭ-bĕ-tet′-ke.
	Fut.,	ĭ-bĕ-te′.
Imper.		ĭ-bĕ-ti′-nuk. Only used in a negative sense, "*ke bĕ-ti′-nuk*," do not start (or move); *i. e.*, "keep perfectly quiet."

To roast.

Inf.		ĭ-ku-ke′.
Ind.	Pres.,	ĭ-ku-kuk′.
	Past,	ĭ-ku-tu′-na.
	Perf.,	ĭ-ku-ket′-ke.
	Fut.,	ĭ-ku-ke′.
Imper.		ĭ-ku-kuk′.

To exchange.

Inf.		ĭ-mne′-we.
Ind.	Pres.,	ĭ-mne-wet′-ke.
	Past,	ĭ-mne′-uŋ̍g.
	Fut.,	(mi′-a) mne′-we.
Imper.		ĭ-mne′-uŋ̍g.

To sleep.

Inf.		kĭ-puk.
Ind.	Pres.,	kĭ-pa-wet′-ke.
	Past,	kĭ-pe′.
	Perf.,	kĭ-pug′-wo. kĭ-pet′-ke; third person plural only.
	Fut.,	kĭ-put′-ke.
Imper.		(ju) kĭ-put′-ke.

To lose (inanimate objects).

Inf.	ĭ-cho′-wa.

There are no changes in this verb, except that *mia* is added to the Ind., Fut. There is no Imperative.

To lose (animate objects).

Inf.		ĭ-cho-rai′.
Ind.	Pres.,	ĭ-cho-rai′.
	Past,	ĭ-cho-rai′.
	Perf.,	ĭ-cho-rat′-ke.
	Fut.,	ĭ-cho-ret′-ke.

To listen.

Inf.		ĭ-shtsu′.
Ind.	Pres.,	ĭ-shtsuk′.
	Past,	ĭ-shtse′.
	Perf.,	ĭ-shtset′-ke.
	Fut.,	ĭ-shtse′.
Imper.		ĭ-shtsuk′.

To count.

Inf.		ĭ-shtaung′.
Ind.	Pres.,	ĭ-shtaunk′.
	Past,	ĭ-shta′-we.
	Perf.,	ĭ-shtaung′.
	Fut.,	(mia) shta′-we.
Imper.		ĭ-shtaunk.

To fall.

Inf.		ĭ-haw′-na.
Ind.	Pres.,	ĭ-haw′-nuk.
	Past,	ĭ-haw′-ne.
	Perf.,	ĭ-haw-net′-ke.
	Fut.,	ĭ-haw′-na (mi), (*mia*).

To push.

Inf.		pat′-ku.
Ind.	Pres.,	pat′-kuk.
	Past,	pat′ke.
	Perf.,	pat-ket′-ke.
	Fut.,	pat′-ke.
Imper.		pat′-kuk.

To feed.

jë-ku′ has the same terminations as pat′-[ku.

To want.

Inf.		ĭ-ki-a′-na.
Ind.	Pres.,	ĭ-ki-a′-na. ĭ-ki-et′-ke, third person only; when "he *wants* you."
	Past,	ĭ-ki-e′.
	Fut.,	ĭ-ki-e′.

The place of the accent is strictly determined by the structure and etymology of compound words. In words composed of a noun and an adjective, the accent is placed on the adjective; thus *di+ki-bi'*, large water, *i. e.*, river; *chi-ka+tyng'*, large substance, *i. e.*, stout; *sa-wi'+juk*, cotton substance or raw cotton. This applies equally to the emphasis in a similar phrase like *pĕ how'-ri*, other, or different people. When the word is composed of an adjective or adverb, with a verb, the accent goes with the verb; thus, *ĭ-shuñ+pu'*, to spread; *ĭ-wo+tu'*, to shut. When composed of a noun and a verb, it follows the same rule; thus, *bĕ-ta+on'-te*, the remainder (*i. e.*, the end stays or remains). When composed of two nouns, one in an adjective sense, the accent is on the qualifying noun, like *mo'+wo*, navel; *du'+hu*, nest or bird-house; *tsu'+di-o*, milk or teat-juice; *tsu'+wo*, a woman's breast; *tsu-wo'+bĕ-ta*, nipple. This rule is almost universal in Bri-bri, and obtains generally in the other languages; the greatest number of exceptions being in Terraba.

In the simplest sentence, the nominative begins, followed by the object, and the verb comes last. When a noun is qualified by an adjective, the adjective follows the noun. In the same way the adverb follows the verb; and the verb closes the sentence, unless it is accompanied by an adverb, or adverbial phrase. In case there are, in addition to the nominative, object, and verb, another noun, governed by a preposition, these latter close the sentence. I strike you; *je be pu, I thou strike.* I strike you hard; *je be pu dĕrere.* The strong man chops the wood well; *wewi dĕrere kar tu boi.* Will you go with me?; *be mia je-ta*, thou go I with. *Ta*, *wa*, and *weñ* (see notes on the nouns) are always added as suffixes to the nouns or pronouns which they qualify, and form a sort of ablative case. But where *weñ* is used in the sense of "where is," it begins the sentence. Whose hat (is this)? *ji sombreno?* Mine; *je'-cha.* How many people are there in your house? *pe bil tsosi be hu-weñ?* people how many are thy house-where? Where is he? *weñ ye 'tso?* where he is? He remained in the middle of the road; *ye onte nyoro shong*, he remained road middle. Give me a chair (or bench), *krŭ-wa' mu'-nya;* chair give me. Give him, *mu'-ye.* Reach me my hat; *je sombreno be ura reska*, my hat thou hand reach. Heat the water; *di ba-ung*, water make hot. The water is hot; *di ba ba-na*, water warm heated (is). Put out the fire; *bowo wo-tu'*, fire extinguish (or close). The fire went out; *bowo ĭ-to'-wa.* Shut the door; *hu shku wo-tu'*, house door shut. Unfasten the door; *hu shku wo-jet'-sa.* Open the door; *hu shku wo-hu'-wa.* Where is my knife? *weñ je tabe?* where my knife (*et so*, to be, understood)? Your knife is there; *be tabe tsosi diya*, thy knife is there. Give me my knife; *je tabe munya*, my knife give. My knife is very sharp; *je tabe akata boi*, my knife toothed good. Go shoot a bird, or go shoot birds; *be ju du tu*, thou go bird shoot. What with? *i-wa?* With a gun; *mokkur wa*, gun with. What kind of a gun? *mokkur is?* gun what kind? Our country gun (blow-gun); *sa konska mokkur*, own country gun. There are no balls (the clay balls or pellets); *mokkur wo ke ku*, gun round (things) no more

(*are* understood). Why do you not make some? *i kuenke be ke mokkur wo juwo?* why thou not gun round (things) make? There is no clay (or material); *mokkur wochika ke ku,* gun round (things) material no more. Is your gun a good one? *be mokkur boi?* thou (thy) gun good? Does it shoot well? *ĭtu boi?* shoot well (or good)? Good morning; *be shke'na?* thou art awake, or arisen (literally, straightened up). Reply; *je* (I) *shke'na. Be ratski;* thou hast arrived (salutation on a person entering a house). *Je ratski,* I have arrived. How are you? *is be 'tso?* how thou (*et-so'-si*) art? I am well; *je 'tso boi.* Where did you come from? *weñg be bete'?* where thou start? Who went with——? *ji re——ta?* who went—— with? I did not see; *ke je wai suna,* not I (*wai* idiom) saw. I do not know; *ke je wai uphchen.* This *wai* occurs nowhere except in these two instances. What did you go for? *iub be re?* why thou went? I went to call my people; *je re je wakipa ĭkiu,* I went I (my) people to call. Are they coming? *yepa ratski?* they come (or arrive? No; I think they have gone away; *au; je hĕnbeku ye micho,* No; I think they have gone. Let us go too; *mishka hekepi,* let us go alike. Where is ——? *weñg——?* He has gone ahead; *ye 't-katke,* he has walked ahead (see note on *ĭ-shku,* in conjugation). Put on your clothes; *be sa-wi' i-u,* thou clothing (cotton) put into.

SECTION II.—MISCELLANEOUS NOTES.

Although the tradition exists that the people of Terraba are a comparatively late emigration from the region of the Tiribis, and although the tradition is sustained by the general resemblances of language, and by the fact that the Brunkas (or Borucas), evidently older occupants of the soil, are crowded into a corner like the Celtic tribes of Europe; yet there are marked differences between the idioms spoken in Tiribi and in Terraba. The Dialects of Southern Costa Rica can be divided into three groups: First, the Bri-bri and the Cabecar; second, the Tiribi and Terraba; and lastly, the Brunka. The three divisions possess many roots and even entire words in common, and may well be compared in their resemblances and differences with the Latin languages. The first group is strongly marked by the short *ĭ* before nearly all verbs and by a generally more musical sound; while the second is harsh, in consequence of the frequent repetition of sound of *z*. The Cabecar *ĭ* before the verb is not so persistent as in Bri-bri, but is more strongly pronounced, approaching more nearly the ordinary Latin or Spanish *i*. The terminations *ung* and *ong* are as marked as the sign of the verb, in the second group, as *ĭ* is in the first. The *z* which almost invariably accompanies this termination, is rarely a part of the last syllable, but is usually sounded at the end of the penultimate, unless when abbreviated into *zu* or *zo*.

A gradual process of change is clearly discernible in these languages. As yet the Bri-bri and Tiribi have been but little affected. But the Cabecar of Coen is absorbing many Bri-bri words because the people of the Coen, although they use their local dialect among themselves, all speak Bri-

bri also, while the latter, as the conquerors, despise the Cabecars and never attempt to learn their language. The Cabecars of Estrella rarely speak Bri-bri, but nearly all understand it, as well as Spanish and some speak English, and words of both these latter languages are gradually being adopted. The Tiribis are too isolated to acquire many foreign words; but their near relatives the half-civilized people of Terraba as well as the neighbors of these latter, the Borucas, are rapidly acquiring Spanish at the expense of the corresponding words of their own language. In a party of five Borucas, there was not one who could count except in Spanish; and one of my Terraba friends could remember no word for girl, except *muchacha* (Spanish), until I suggested (supported by analogy) the word *wa-re'* (woman), when he remembered that he had heard some of the old people use *wa-wa-re'!* In like manner, he persisted in giving me the Spanish, "*lucero*" for star, besides many other words.

Many roots run through the entire group of languages unchanged, or with changes so trifling that they are not worthy of note. Again sometimes the root varies while the ruling idea is the same. An illustration of this last case is the following: In Bri-bri, to forget is *hĕn-i-cho*; to remember is *ke hĕn-i-cho*, from *ke* not, *hĕn* the liver, and *i-cho* to lose. To think is also *hĕn be-ku* (probably from *be ket-ke*, ready). Liver in Tiribi is *wŏ*, in Terraba *wo*, and in Cabecar *her*; while to think is, in Tiribi *wo tnizung*, in Terraba *woi-du*, and in Cabecar *her-wik*. The acts of thought, memory, &c., have been attributed to the liver, with about as good reason as we yet place the seat of sentiment in the heart.

In Bri-bri, to lie down is *tu is*, to throw down; imperative *me* (yourself) *tu is*. In Terraba *tush ko* (down) is used in the same manner; *fa tush ko*, thou sit down, and *fa bu tush-ko*, lie down (*bu*) long.

Changes of roots are illustrated by the following. In Bri-bri, *kĭ-puk'* is to sleep, and a hammock is *kĭ-pu'*. In Cabecar a bed is *kŭ-pu'-gru*, in Tiribi and Terraba it is *bu'-kru*; and in Brunka *kap* is to sleep.

In Brunka a ghost is *i-wik*, and a shadow is *ka-wik'*, and a devil or evil spirit is *kag'-bru*. In Bri-bri, a ghost, or spirit of a dead person is *wig'-bru*. In Cabecar, a shadow is *wig'-ra*, while in Tiribi it is *ya'-gro*, and in Bri-bri, *si-ri-u'-gur*, thus connecting the word in Bri-bri for ghost, or departed spirit, with that for shadow by means of the allied idioms, although without the intermediate changes of the root, it would not have been demonstrable.

It is evident that the Cabecar *mog-i'*, straight, and the Bri-bri *maw'-ki*, true, are identical. Although the Bri-bri word *si'-gua*, foreigner, has been replaced in the other languages, by other words, it remains in the Terraba, as a compound, in the name of the banana, *bin-sigua*, evidently "foreign plaintain," from *bing*, a plaintain; because it may have been introduced at a later date than the larger fruit, and when the word *sigua* was yet in current use.

Again, the idea changes, and with it, words from other roots come in, thus: lightning, in Bri-bri is *ara wo'-nyn*, "the thunder flashes;" the

Tiribi *zhgu-ring'* and the Terraba *zhu-ring'*, seem to be specific; but the Cabecar, *kong-wo-hor'-kn* is "the atmosphere burns," while the Brunka *ji'-kra* is simply "fire."

Like the two or three cases of imperfect plural in Bri-bri, already mentioned, the Terraba has a single plural word; or rather only an approach, a sort of transitional form. *Zhgring* is a rib, and *zhgring'-ro*, the ribs in their collective sense, rather as the bony case of the thorax, than as the several bones.

As stated above, the compound words in the vocabulary of Bri-bri are divided by a + sign between the component parts. In the other languages, there are doubtless many that have not been properly separated, because I have not ventured to make theoretical divisions, and have only separated those that were obviously compound. My less perfect acquaintance with them has not warranted me in this step, nor in the probably unnecessary detail of analysis to which I have subjected the language of Bri-bri.

In Terraba the 3d person, singular, pronoun *kwe*, while not varying for gender or number, has three forms which always appear according to a peculiar condition, thus:

he, she,	(sitting or lying down)	so'-kwe.
" "	(standing)	shon'-kwe.
" "	(going)	her-shon-kwe'.

In Brunka, I, thou, he, (or she) and we, (*a-dĕ-bi'*, &c.,) are used with the termination *dĕ-bi'* whenever they occur alone. When combined with other words in a sentence, the first syllable only (*a*, *ba*, *i*, and *ja*) is used. The termination is almost an integral part of the word and must be used when alone. This is the reverse of the termination *re* in Bri-bri, which is rarely used except in a sentence, and then only for euphony or emphasis, and at the option of the speaker.

Chapter III.

VOCABULARY OF THE LANGUAGE OF THE BRI-BRI INDIANS.

[Note.—In this, and in the accompanying vocabularies, the vowels have the same sounds as in Spanish, unless marked with a special sign; *ĕ* is pronounced as in English *met*; *ĭ* as in *pin*; *ŭ* as in *mum*. *J* has the sound as in *John*; *ng* as in *thing*; *ñg* like the French nasal *n*; *šh* like *ch* in the German *ich*; *h* is aspirated as in English. A few words having unusual vowel sounds are noted separately, not to add unnecessary complication of conventional signs; like *si-ai'*, blue and *ku-ku'*, ear.

Compound words are written with a + sign between the component parts. Accent is of great importance, the change in position of the ac-

cent sometimes changing the sense of the word entirely like *ĭ-juk'* to drink, *i'-juk* earth, soil.]

to ache	ĭ-dĕ-li'-na	See *pain.*
to adhere	ĭ-ba'-tsa-wa	See *against.*
afraid	sŭ-wa'-na	
afterwards	e'-wa	Not *i'-wa*, interrogative, "what with."
again	i-să-ka'	See *also.*
against	ĭ-bĕ-tsu'-wa	See *to adhere.*
ago	er'-a-pa	Immediately past time.
	en-i-ai',	Hours ago; this morning.
	nyo-ngo'-ni	Very long ago; days, months, years.
to agree	ĭ-shun'-lu	See *to arrange.*
	nyi'+wo-yu	*Nyi*, together.
to aim	ĭ-shun'-sa-u	
air	koŋ'+shu-wang	*Koŋ*, see country; *shu-wang*, from *si-wang'*, wind.
alike	nyi+ke'	*Nyi*, together.
	nyi+shtsei'	Exactly alike; *tsei*, much, applied to words or two people speaking alike.
alive	tse'-ka	See *awake.*
all	seng	
	o-ri-te-ne'	
alligator	to-rok'	
alone	e'-kur	*E* (*et*) one.
	e'mi	Used in the sense of *only.*
alongside	i-yaw'-mik	
already	je-bak'	
also	i-să-ka'	See *again.*
always	shu-ar'-i-a	
angle	bĕ-ta'	A point; the angle of a surface or the corner angle of a solid.
	si-chi'-a	The angle of a prism; see *square.*
angry	o-ru'-na	
ankle	o-ra-bo'	
ant,	tsa'+wak	*Wak*, people, tribe.
ant-eater	u-ri'	*Myrmecophaga jubata.*
	te'+u-ri	*Tamandua 4 dactyla; te*, a forest clearing; from its being often found in such places.

to arise	ĭ-ku′-ku	
arm	u-ra′	
	u-ra+krong′	Upper arm
	u-ra+nya′-we	Fore-arm, *nya′-we*, belly; see *calf of leg*.
to arrange	ĭ-shun′-lu	To arrange, or agree on a question.
	ĭ-mu boi′-kli-na	There is no one word for to arrange *things* in their places; *i-mu*, to put, *boi′-kli*, pretty good; see introductory notes.
to arrive	ra′-tski	
arrow	ka′-but	Of the various forms of arrows in use, each has also a specific name.
ashes	mu-nu′+chi-ka	*Chi-ka*, material.
to ask	ĭ-cha′-ku	From *i-chu*, to say?
aunt	mi′+a-la	*Mi*, mother; *la*, diminutive.
awake	tse′-ka	See *alive*.
to awake	ĭ-shke′-na	*Shke*, straight.
away	ĭ-mi′+bak	*I-mi′-a*, to go; *bak*(*je′-bak*) already; already gone.
axe	o	Also *shoulder-blade*.
back	shung′+wo	
small of back	ju′+wo	
backwards	tsink′-a	
bad	su-ru′-i	
	su-ru′-na	Used to express disapproval.
bag	tsku′	A native net bag.
bald	chu-i′	
banana	chi-mu′	
bare	sum′-ĕ	See *naked*.
bark	kar+kwo′-lit	*Kar*, tree; *i-kwo′-lit*, skin.
basket	šhku	
bat	da-kur′	
to bathe	a-kwok′	
to be	et-so′-si	In a place; also *to have*.
beach	tsong′+kin	*Tsong*, sand; *kin*, region.
bead	bi′+wo	*Bi*, (?) corrupted from English *bead*; *wo*, round.
beak of bird	du′+ka	*Du*, bird; *ka*, tooth.

bean	a′-tu+wo	
to bear	su′-na	To bear young (human).
	pa′-na	To bear young (inferior animals).
beard	ka′-luk	
beast	du bi bi′-wak	*Bi*, the devil, or anything mysterious; *wak*, tribe. There is no word exactly equivalent to ours for "beast." Each animal (as well as plant), has it specific name, and *du*, properly belonging to birds, is usually applied if the species is unknown; *bi-wak* is only used in a collective sense.
to beat	ĭ-pu′	To strike, to whip.
	ĭ-bu-ra′+ung	To beat, as on a drum.
bed	a-koŋ′	
bee	bur	
	bur′+wak	*Wak*, tribe.
before	keng′+we	*We*, where.
behind	diu′+shent	Behind in the abstract; see *in front*.
	bĕ-ta′+ka	At the tail of a line; immediately behind; *bĕ-ta′*, a point.
belly	nya′+we	*Nya*, see *dung*; *we*, where.
below	is′+kin	*Is*, down; *kin*, region.
belt	ki-pam′+wo	*Ki-pam*, from *ki-par*, waist.
bench	krŭ-wa′	
to bend	ĭ-wo+shki′+ung	Into a ring; *shki*, a circle.
	ĭ-chung′+wa	To bend at an angle without breaking.
	ĭ-ko-kut′+wa	To bend into a curve.
bent	ko-kutk′	
better	boi′+na	*Boi*, good.
between	shu+shong′	See *middle*.
beveled	sho-utk′	Equally applied to a prismatic solid, or to the cutting off the corner of a surface; see sloping.
bird	du	
to bite	ĭ-kwe′-wa.	
bitter	bĭ-chow-bĭ-choi′	

black	do-ro-roi′	Also very dark blue.
blade	i-wa′	
blind	wo-ju+be′-ie	
blood	pe	
to blow	woi-ku′	With the mouth; *ku* the tongue.
	be-tsir′-ke	*Si-wang be-tsir′-ke*, "the wind blows."
blue	si-ai′	Last syllable prolonged.
	do-ro-roi′	(Black) very dark blue.
blunt	ke+a-ka′+ta	*Ke*, not; *a-ka′*, tooth; not edged.
	ke+bĕ-ta′+ta	*Ke*, not; *bĕ-ta′*, point; not pointed.
body	wak	Also *tribe*, *race*, *people*.
bog	doch′-ka	See mud.
boil	squek	A furuncle.
to boil	ĭ-tu+wo′	
bone	di-cha′	
bones	di-che′	For notes on this plural, see introduction.
border	iu-ku′	
both	et+et	*Et*, one.
bottle	ko-ku′	See calabash.
bow	shkum-me′	
boy	kŭ-be′	
branch of tree	kar′+u-la	*Kar*, tree; *u-la* (*u-ra*) arm.
brave	we′-bra	
bread	i-nya′	See cake.
to break	ĭ-pa-na′-na	Hard things,
	bu-tsa′-na	A string; *tsa*, a string.
breast	be-tsi′	
breast of woman	tsu′+wo	Also teats of lower animals.
breath	si-wang	Wind.
breech-cloth	ki-par′+wo	*Ki-par*, the waist.
bright	du-ru′-ru-i	
to bring	ĭ-tsunk′	See to carry.
broad	sho	
broom	wush′+kru	
brother	yil	Always preceded by a proper name or a pronoun.
brother-in-law	ar′-ŭ-wa	

bug	——	There is no generic word. Every prominent species has its name, usually consisting of an adjective, combined with *wak*, tribe.
bundle	dli	
to burn	I-nyor′-ka	
to bury	I-bru′	
bush	kar+tsi′-la-la	*Kar*, tree; *tsi-la-la*, little.
"bush dog"	ro′-buk	*Galictis barbata.*
butt	nyuk	See rump.
butterfly	kwa	
to buy	tu-eng′-ke	
cacao	si-ru′	Also chocolate.
cake	i-nya′	
calabash	ko-ku′	Applied to entire calabashes with a small opening, for water bottles.
	kyong	Cut in half for cups.
calf of leg	klu+nya′+we	*Klu*, leg; *nya′-we*, belly.
to call	i-kiu′	To summon, to name.
to call out	i-ya′-na-tsu	The accented *a* like *a* in far.
cane	kar	A walking cane, or stick.
	u-ka′+kur	River cane.
	u-pa′+kur	Sugar cane; see *sugar*.
caoutchouc	si-ni′+chi-ka	*Chi-ka*, material.
care (take)	e′-no-e′-no	
	me+haw′-na-mi	*Me*, yourself; see future tense to fall.
cataract	jol	Also a spring.
to catch	i-krung	
centipede	ko	*O* very long.
chaff	i-ku′	
to chase	i-tu′+tiung	
to cheat	wo′-ju	
cheek	onk	
chicha	bo-ro′	A light beer made from maize.
chief	bo-ru′	
child	la′-la	(*Tsi′*) *la-la*, little.
chin	a-ka′+tu	*A-ka′*, teeth.
chocolate	si-ru′	
to chop	i-tu′	Also *to shoot.*

clean	me-ne′-ne	
	ji′-ji	Also *smooth.*
	i-shung+boi	*I-shung*, inside; *boi*, good.
to clean	ĭ-pa′+skwo	*I skwo*, to wash ; the outside of anything.
	ĭ-tu′+skwo	The inside of a vessel.
clearing	te′	A cleared space in a forest.
close	tsi′-net	Near.
	ku-ku′-ni	Near.
to close	ĭ-wo+tu′	
cloth	di-tsi′	Made from bark.
	sa-wi′	Made from cotton.
clothing	sa-wi′	Cotton.
cloud	mo	The generic word for all clouds.
	shi	A very dark rain cloud.
club	kir′-u	A long stick for fighting.
coal	bo′-wo+ka	*Bo′-wo*, fire.
cold	se	Only applied to the atmosphere, as *koñg+se′*, a cold day.
	se-señg′	Used in all other connections.
comb	kash	
to comb	kash′+kru	*Kru*, to scrape.
to come	i′-na	(Imperative) "come here,"
	ĭ-shku′	To walk.
to complete	o-ro′-na	
compressed	su-tat′+ke	*Su-tat′*, flat.
to consider	be-kĕt-se′-ke	
constricted	su-litk′	Applied to a constriction between two larger parts.
contracted	su-litk′	Applied to a constriction between two larger parts.
to converse	la′-ri-ke	Only used in the sense of a present participle, conversing.
to cook	ĭ-lu′	
coon	tsi	*Nasua.* There are specific names for the two species, formed by adding adjectives. There seems to be no name for *P. lotor*, which is very rare.
corn	i-kwo′	Maize.

corpse	al′-ma	Can this be Spanish, *alma*, soul?
cotton	sa-wi′+juk	*Juk*, material.
to cough (v) cough (s)	to	The resemblance to the Sp. *tos*, a cough, is probably only a coincidence.
country	koŋ̍g koŋ̍g+ska	*Koŋ̍g* is used in innumerable compounds. Not only is it used in the same manner in all the allied dialects, but in Brunka, it occurs as *kak*, the sun. Nearly all words relating to country, air, day, atmosphere, sky, earth, in short, the general physical surroundings, contain it as an integral part, *Koŋ̍g+ska* is the country inhabited by any people.
cousin	——	Cousins are called "brother" and "sister," even if several degrees removed.
to cover	pa+bĕ-ku′ ĭ-šhku+pa+bĕ-ku′	*Pa*, skin, covering, surface; *ĭ-bĕ-ku*, see to pack; to cover a solid object. To cover a vessel to shut a book.
coward	sŭ-wa+na	See afraid.
crab	ju-wi′	
crazy	i-li′-na	*Ye li′-na-ka*, "he is crazed."
crooked	ki-tunk′	
cup	kyoŋ̍g	See calabash.
to cut	ĭ-nyu′ ĭ-tu′	Without chopping. With chopping.
cylindrical	a-ra-bo′+wa	
damp	mong′-mok	
to dance	klu′+ptu	*Klu*, the foot; *ptu*, the sole.
dark	tset-tsei′	Also any dark color, especially dark brown.

darkness	koñg+tu-i′-na	"The day darkens" (either from clouds or towards night).
daughter	je+la+ra′-kur	*Je*, my, *la* (*la-la*) son; *ĕ-ra′-kur*, woman. For note on *je*, see *son*.
daughter-in-law	jak′+ĕ-ra	See father-in-law. *ĕ-ra*, (*ĕ-ra′-kur.*)
day	nyi′+we	Contradistinguished from night.
	koñg	Used in all other connections; as *koñg se*, a cold day.
to-day	in′-ya	
to-morrow	bu-le′	
day after to-morrow	bui′+ki	This *ki*, is apparently "more."
3d day future	m-nyar′+ki	*M-nyat*, three.
4th " "	keng′+ki	*Keil*, four.
5th " "	skang′+ki	*Skang*, five.
6th " "	ter′-i+ki	*Terl*, six.
7th " "	ku′-gi+ki	*Ku′-gl*, seven.
8th " "	pai′+ki	*Pa′gl*, eight.
9th " "	koñg+su-ni′-to	*Su-ni′-to*, nine.
10th " "	koñg+d-bob′	*D-bob*, ten.
11th " "	koñg+d-bob+ki+et′	See eleven.
yesterday	chi+ki′	
day before yesterday	bo′+kli	*Bo* (*but*), two.
3d day past	m-nyon′+li	
4th " "	ka′+ri	
5th " "	skan′+i	
dead	i-da-wo′+wa	See *to die*.
debt	mu′+i	See *money*.
deep	i-shu+tyñg′	*I-shung*, inside; *tyñg*, large; large inside.
	(di)+tyñg′	Deep water.
	wo+kŭ-chutk′	Applied to a *deep* vessel, when the mouth is contracted.
	wo+bli	The same, with the mouth not contracted.
deer	su-ri′	Large species.
	su-ri+ma-ru′	Small species; ma-ru′, reddish.

to depart	mi+cho′	Also perfect, indic., of verb, *i-mia* to go.
to descend	ĭ-u′+mi	*ĭ-u*, to put in; *i-mi′-a*, to go.
devil	bi	Also ghost, or evil spirit.
dew	mo′+wo-li	*Mo*, cloud; *wo′-li*, drop.
to die	i-da-wo′	
different	hau-′ri	
direction	weiñg	See *where*.
dirt	ka′-mu-ni	
disordered	cho+ri′-li-ĕ	
to dissolve	di+a′-na	*Di*, water.
district	kin	See *region*.
	koñg	See *country*.
to disturb	tiñg′-we	
to dive	tsant′-kuk	
doctor	a-wa′	
done	o-ro′-ni	Applied to a completed business.
	e′-na	"There is no more."
door	hu′+shku	*Hu*, house.
double	bit+ung′+wa	*Bit* (*but*) two; *ung*, to make.
to double	ĭ-wo+puñg′	
down	is	In compounds.
	is′+kin	*Kin*, region (used alone).
to drag	ĭ-ku′+mi	*Mi* (*mi′-a*) to go.
dragon-fly	ki-bi′-a	
to dream	kab′+sueng	*Ka-puk′*, to sleep; *sueng*, to see.
to drink	ĭ-juk′	
to drive	ĭ-bĕ+ku′	*I-ku*, see to drag.
drop	wo′-li	
drum	se-bak′	
dry	si	Like wood, fit for burning.
	si′-na	By evaporation, like clothes after washing.
	po-poi′	Wiped dry.
	mong′-mok	In a less degree than the other words; but more or less applicable in all cases (partially dry *i.e.* damp). The above are the common usages but are not absolute, the various words being sometimes used interchangeably.

dung	nya	See cake.
dust	koñg'+mo-li	*Koñg*, see note to country; *mo*, cloud; *li* is used in two or three connections with objects in, or derived from the atmosphere, like dew, rain, &c.
eagle	sar'+puñg,	*Sar*, red monkey; *puñg*, hawk.
ear	ku-ku'	*U*, like the German *ü*.
early	bu-la'-mi	*Bu-le'*, to-morrow?
earth	i'-juk	(Soil). Not *ĭ-juk'*, to drink.
earthquake	i	English *e*.
to eat	ĭ-kŭ-tu'	This word is never used in the sense of eating a meal; then *jĕ-ku'*, to feed, is always used.
echo	i-o-ro'-te-nu	
eddy	ir-a-me'	
edge	iu-ku'	
egg	du'+ra	*Du*, bird. In place of "bird," the specific name of the animal is generally given; thus: *to-rok'+ra*, alligator egg.
elastic	ki-tsung'-ki-tsung	Like rubber.
	kras'-kras	Like a switch.
elbow	u-ra+ku-ching'+wo	"Knee of the arm."
	u-ra+knyi'+nyuk	"Heel of the arm."
empty	wu'-ji-ka	See naked.
	wa-ke'-ta	
to empty	ĭ-wu'-ji-ka	
	ĭ-wa-ke'-ta	
	ĭ-tu+tsung	To pour out.
end	bĕ-ta'	Point.
ended	e'-na	"It is all gone."
	o-ro'-ni	Applied to affairs.
enough	wed	
enemy	bo'-ruk	
to envelop	ĭ-bĕ-ku'-wa	
equal / equally	nyi'-ke-pi	*Nyi*, together; *he'-ke pi* alike.
equivalent	ske	
erect	shke'-ka	Perpendicular; see straight.

even	nyi+šhke	*Nyi*, together; *šhke*, level; in a straight line.
	tski-tski′-a	Even in a pile.
	d-ra-d-dai′	Both of these words mean equal on the edges in a pile, like bricks in a wall, or the cut leaves of a book.
	nyi′+es	
evening	tson′-ni	Also late.
to exchange	mne′-we	
to expect	ka′-ble	
to extinguish	ĭ-wo+tu′	Also *to shut.*
eye	wo′-bra	
every	o-ri-ten-e′	See *all.*
	seńg	
face	wo	See *round.*
to faint	si-wańg+e′-na	*Si-wańg*, wind; *e′-ha*, to finish.
to fall	ĭ-haw′-na	
family	di-jam′	
far	ka-mi′-mi	
fast	bet′-ku	Rapid.
	dĕ-re′-re	Secure, hard.
fat	ki-u′	Fat, grease or oil of any kind.
	yol′-ta	A fat animal.
	chi′-ka+tyńg	Fat person; see stout.
father	ji	Always used with a personal pronoun or the name of the person; *je ji*, my father; or with an exclamation, *ah ji*, oh father.
father-in-law	jak	
to fear	su-wa′-na	
fear	su-wa′-na	
feast	sa+bŭ-ra′+ung	*Sa*, we. To feast, to dance and to beat drums are ideas so intimately united in the minds of these people, that the same word is generally used indiscriminately for all three.
feather	du′+kwo	*Du*, bird; *kwo*, see scale, skin, nail, &c.

to feed	jč-ku′	See *to eat* and *food.*
female	la′-ki	*La* = *ra* in *č-ra′-kur*, woman.
fever	tak	Spleen.
few	et′+ket wa-wa′-ni	*Et*, one. Also *less.*
fierce	bu-kwe′-wa	
to fight	nyi′+pu	*Nyi*, together; *i-pu*, to strike.
to fill	i-u′	Also *to put in.*
to find	ĭ-kwon′-ju	
fine	wis-wis′-i	Like either a thread, or powder.
finger	u-ra′+ska	*U-ra*, arm.
to finish finished	e′-na o-ro′-ni	See ended.
fire	bo′-wo	
fire-fly	ku′wo ka-tu	Specific. The small flies. The large phosphorescent *elater.*
fire-wood	bo′-wo+tak	*Bo′wo*, fire; *tak*, a piece.
fish	ni-ma′	This is at the same time generic, and is the specific name of the best food fish in the country; the other 15 or 16 species bearing other names.
fish-scale	ni-ma′+kwo	*Kwo*, see skin, nail, &c.
flash	wo′-nyn	
flat	su-tat′ šhke	Like a board, table, &c. Like a floor, a tract of country.
flea	ki	
flesh	du′+ra chi-ka′ du+ra′+chi-ka	*Du*, animal; *chi-ka′*, material; often both words are combined, and more often the name of the animal is used with *chi-ka*, thus *raca chi-ka*, beef.
floor	hu+shiung	*Hu*, house.
flower	ma′-ma	See plaything.
fluid	di+sč-re′-re a-bas′-a-bas	Watery. Like thin mud.
fly	si-chu′	
to fly	i-un′+e-mi	*I-mi′-a*, to go.
fog	mo	See *cloud.*

to fold	ĭ-wo+puŋ'	See *to double*.
folded	chu-no'-wa	
to follow	ĭ-ju'+ki	
food	jĕ-kuk'	
foot	klu	
force	ke'-sin-kwa	
to forget	hĕn+ĭ-cho'	See introductory notes.
forehead	wo'+tsoŋ	
foreigner	si'-gua	
forest	koŋ'+juk koŋ+yi'-ka	*Koŋ*, see country; *juk*, material.
fragile	to'-to	See *tender*, *weak*.
free	ha'-si	
fresh	paŋ-ri	
friend	ja'-mi	See *family*.
to frighten	sŭ-wa'+ung	*Sŭ-wa-na*, afraid; *ung*, affix, to make.
frog	ko-ru'	
tree-frog	wĕm	
front	ai-u'-shent	In front, see behind.
froth	i-shu-ji'	
fruit	kar+wo	*Kar*, tree; *wo*, round, a lump.
full	chik-li i-e'-na	This is probably not the Spanish *llena*, but *e'-na*, ended; *i. e.*, "no more can be put in."
gall	šhke	
genitals	ke ma-lek'	Female. Male, human; see *penis*.
to get	ĭ-kruŋ	
ghost	bi wig'-bru	See *devil*.
gift	ti-e'	
girdle	ki-pam'+wo	See *belt*.
girl	ta'-ji-ra ŭ-la-bu'-si	Before puberty. After puberty.
to give	ĭ-mu'	"Give me," *i-mu'-nya*; "give him," *ĭ-mu'-ye*, or *i-mu-ye-ta*. This is the same word as *ĭ-muk*, to put. To give anything to a person is consequently to put it with him, *ĭ-mu*, to put, *ye*, he, *ta*, with.

glad	išh-tsin′-ĕ	
to go	ĭ-mi′-a ĭ ju	For notes on this word see introduction, and especially the conjugation.
God	si-bu′	
good	boi	Also clean, pretty. Emphatic *boi′-hi.*
to grab	ĭ-krung	
grandfather	re-wu′+je-ke	*Je-ke;* see *old.*
grandmother	nu-wi′+je-ke	
to grasp	ĭ krung	
grass	kong′+chi-ka	*Chi-ka*, material, is here used contrary to the sense explained, (see material) because *kong +juk*, having the same etymological meaning, is applied to forest.
grasshopper	di′-tsik	
gravel	tsong′+wo	*Tsong*, sand.
grease	ki-u′	See *fat.*
green	tsĕ-bat′-tsĕ-ba	See *wet.*
grief	hed-i-a′na	See *sad, sorry,*
to grind	ĭ-woh′	
to grow	de-tyng′+eh ĭ-tar+an′-o ĭ-tar+ar′-ko	A plant. A person or animal.
guatuso	shu-ri′	*Dasyprocta cristata.*
gun	mok′-kur	
hair	konsh′-ko ko+juk	Of the head. Of the body; *juk*, material. See *leaf.*
half	shong′+buts	*Shong*, see *middle, between; but*, two.
hammock	kĭ-pu′	See *to sleep.*
hand	u-ra′+šhkwe	See *finger;* also introductory notes.
handle	kut+a′	*Sister; tabe kuta*, knife handle; the sister of the blade!
to hang	ki-chat′+ku ĭ-mo+wo′+ka	By tying, like a hammock; *ki-cha′*, a string. By simply hooking up, without tying; although *i-wo′-mo* is a knot.

hard	dĕ-re′-re	This word has as many significations as its equivalent in English. It applies to substance, strength, rapidity, and difficulty.
to have	et-so′	See *to be.*
hawk	puŋ̃g	
he	ye	Also *she.*
head	wo′-ki	
to heal	boir′+ke	*Boi*, good.
heap	i-ra-pa′	
to hear	išh-tsu′	
heart	me′+wo	
heat	ba	
to heat	ĭ-ba′+ung	*Ung*, affix, to make.
heavy	nyets	Usually used with *very: oru+nyets.*
heel	klu+knyi′+nyuk	*Klu*, foot; *nyuk*, butt.
here	i′-nya	In this place.
	i-e′+ku	In this direction; see *there.*
to help	chŭ-ki′-a-mu	
high	koŋ̃g+šhke′	*Shke*, perpendicular.
hill	koŋ̃g′+bĕ-ta	*Bĕ-ta*, a point; the point of the country; also a mountain.
	u′jum	Applied to all hills or peaks not covered with forest.
hilt	kut+a′	See handle.
hip bone	te′+wo	
hip joint	di-che′+wo	*Di-che*, bones.
to hold	ĭ kruŋ̃g	
hole hollow	ĭ-wo′+an	Any hole, whether a perforation or a cavity.
honey	bur′+di-o	*Bur*, bee; *di-o′*, juice.
hook	bi-ko-ru′	
horizontal	ki-pak′	See *to sleep*, and intoductory notes.

hot	ba ba′-ba	But one syllable is used when in combination with another word, as *koŋ̃ ba*, hot day; when used alone the syllable is repeated.
	ba+shki-ri′-ri	*Shki-ri-ri*, (*tski-ri′-ri*) yellow; this is used in exaggeration, "yellow hot," as we say "red hot," and is often applied to the weather, food, &c.
	pa+li′-na	(*Ba+i-li′-na*) "boiling hot," similarly used when one is perspiring freely.
house	hu	
how	im′-a	
to hum	ĭ-bor+a-ru′	*Bor*, (*bur*) bee?
humming-bird	bĕ-tsung′	
hungry	dĕ-wo-be-li′-na	
to hunt	ĭ-je-bu′-rik	To hunt game.
	ĭ-ju+lu′	*Ju*, auxiliary; to hunt anything lost.
husband	je+wim′	*Je*, my. See note to son.
hush	sŭ-waiŋ̃+bru′-wo	*Sŭ-wang*, wind.
I	je je′-re	*Re* is a sort of emphasis, added occasionally to all the personal pronouns except *ye-pa*.
if	mi-ka-re′	
to ignore	bru	*Bru ji*, "I do not know who."
	eh′ke	Used only alone, as a reply, while *bru* takes its place in a sentence, as above.
iguana	bwah	
immediately	er′+a-pa	In the past.
	sir′+a-pa	In the future.
in	i-shuiŋ̃′	
inclined	o-utk′	See sloping, beveled.

inside	wĕsh′+kin hu′+shuŋ̃g i-shuŋ̃g	These two words are applied to the inside of a house; while i-shuŋ̃g is restricted to the inside of a vessel, the interior of the body, of a hollow tree, a box or any other comparatively small space.
instead	ske′	
instep	klu+tsing′	
to interpret	ju-ste′+chu	*I-chu*, to say.
intestines	nya′+kĕ-bi	*Nya*, dung; see *belly; kĕ-bi*, snake.
iron	ta-be′	Also knife; anything made of iron; see *pot*.
it	ĕ-hi′	
jar	ung	
jaw	ka′+ju-a	*A ka*, tooth.
to jerk	ĭ-kunt′-sa	
jigger	ki′+la	*Nigua*; *Pulex penetrans; ki*, flea; *la* diminutive.
to join	nyi′+wo-ju	*Nyi*, together; see *to make, to sew*.
joint	ki-cha′+wo	*Ki-cha*, a tendon, a string; *wo*, a lump.
juice	di-o′	Any fluid expressed, like whey from curd; milk from the breast, honey, &c.
to keep	ĭ-bru′	
kidney	hak	
to kill	ĭ′-da-wo′-wa	See to die.
kind	boi′+sen wak	*Boi*, good; in disposition. Class: see *tribe*.
knee	kŭ-chi′+wo	
knife	ta-be′ ta-be′+la	See *iron*. *La*, diminutive; a small knife.
to knock	ĭ-pa′+pu ĭ-bu-ra′+ung	*I-pu*, to strike. See *to beat, feast, to dance*.
knot	ĭ-wo′+mo	*Wo*, round; *mo* (*ĭ-mao′*) to tie.
to know	uph-chen′	
lame	mu′-ya	
language	ŭ-shtu′	

large	ki-bi′	Simply large. When applied to a stream (*di*+*ki-bi′*,) it means river, "large water."
	tyŋ̍g	The commonest form; when applied to water it means deep.
	bru′-bru	Oftenest applied to animals and to domestic utensils.
	tyŋ̍g′+bru	Very large; more emphatic than the preceding forms.
last	bĕ-te+ka	*Bĕ-ta*, point.
late	tson′-ni	See *evening*.
to laugh	ma-nyu′	
lazy	jĕ-ke′-i-a	
to lead	u-ra′+yu+mi	*U-ra*, arm; *mi* (*ĭ-mi′-a*) to go.
leaf	sig	Of a plantain, or other large leaf used for wrapper, or for a receptacle for food, &c. The Mosquito word *sic*, from the same root, means a banana.
	kar′+ko-juk	Of a tree, in a collective sense; *kar* tree; *ko′-juk* see *hair*. The idea is the same and the distinction is made by *kar*, the name of a person, a pronoun, &c.
	kar′-ku	*Ku*, tongue; a single leaf.
to leave	ĭ-hu′+unt	*Hu*, house.
left hand	u-ra+bŭ-knick′	*U-ra*, hand, (arm).
leg	klu′+kĕ-cha	
to lend	dĕ-pe′-te-ju	
less	wa-wa′-ni	Really *few;* there is no other word.
to let	on′-si	Imperative; *on′-si tso-si*, *tso-si* (*et-so-si*) to be; "let it alone."
to lick	ĭ-ku′+juk	See *to suck*.
to lie	kon′-shu	
to lie down	ĭ-tu+is′	*I-tu*, to throw; *is*, down.

to lift	ĭ-ku′-kn	
light	su-ru′-ru-i	(White), light colored.
	lu	*Koŋ̃g+lu*, daylight; *bor+lu* (*bowo+lu*) fire light.
	ho bo′-bra	Light in weight.
lightning	a-ra+wo′-nyn	*A-ra*, thunder; *wo-nyn*, flash.
lips	ku′-kwo	*Ku′*, tongue; *kwo* (*i-kwo-lit*) skin.
to listen	išh-tsu′	
little	tsɪ′-la-la	
	la′-la	Applied to a child.
	la	Diminutive; used with various nouns; *di+la*, rivulet.
a little	wa-wa-ni	Local pronunciations.
	wi-ri-wi′-ri	
	wi-di-wi′-di	
	bi-ri-bi′-ri	
liver	hĕn	
long	bi-tsing′	
to look	ĭ-sauŋ̃g′	
to look for	lu	Always used with the auxiliary *ju*; *ju+lu*.
to loose	ip-tsu′	See *to untie*.
to lose	ĭ-cho′	This is rather a verbal root than an independent word; see to remember and forget. In other cases it carries the terminations *wa*, and *rai*; see notes on the conjugations.
lost	cho′+wa	
	cho+rai′	
louse	kuŋ̃g	
lump	wo	See round.
macaw	pa	Green species.
	kŭ-koŋ̃g′	Red species.
maggot	hu′+nya	
maize	i-kwo′	
to make	ĭ-ju+wo′	*Ju*, auxiliary; *wo*, complete.
male	we′-nyi	
man	we′-wi	

many	tsei	See much.
how many,	bit	Impersonal.
	bil	Personal.
so many	išh'-ke	
marsh	doch'-ka	See *mud, bog,*
material	juk	Any fibrous, or not compact material; as cotton, *sa-wi'+juk;* leaves of a tree, or hair of the head *ko+juk.*
	chi-ka'	Any homogeneous substance; as *si-ru'+chi-ka,* cake chocolate; *su-ni'+chi-ka,* deer meat; *si-ni'+chi-ka,* caoutchouc. Only one exception to this rule exists, see note to *grass.*
meadow	sok	
measure	ya-ma-un'-ya	
meat	du'+ra	See note to flesh.
	chi-ka'	
medicine	kŭ-pu'-li	
metal	nu'-kur	Applied derivatively to money. I have heard quicksilver called *nu-kur'+dio,*" metal juice.
midday	di'+bĕ-ta	*Di-wo,* sun; *bĕ-ta,* point, summit.
middle	shu+shong'	*Shu* is used in nearly all words where the width is a component idea; see *wide, narrow, between, inside; shong,* see *half, between.* In a combination, *shong* only is used; thus *nyo-ro'+shong,* the middle of the road.
midnight	kong+shong'+buts	*Kong,* see day; *shong'+buts,* half.
milk	tsu'+di-o	*Tsu,* breast; *di-o,* juice.

mine	je′+cha	*Je*, I; *cha*, sign of possession.
mistake	hĕn+cho′+wa	See to *forget, remember, think.*
mole	skwe,	Also rat, mouse, &c.
money	nu′-kur	See *metal.*
monkey	sar	*Ateles.*
	wib	*Mycetes palliatus.*
	hyuk	*Cebus hypoleucus.*
month	si	*Si-wo*, moon. In counting, *si+et* one month, &c.
moon	si′+wo	
more	ki	
	ku	
morning	bu-la′-mi	See early; *bu-le′*, to-morrow.
	en-i-ai′	"This morning," already past; see *to-day, here, now.*
mosquito	shku-ri′	
mother	je+mi′	*Je*, my; see note to *son.*
mother-in-law	wa′-na	
mountain	koŋ′+bĕ-ta	See *hill.*
mouse	skwe	Also *mole, rat.*
mouth	ku	Of an animal.
	nyuk	Of a river; see rump.
to move	i-sku′	
much	tsot-tsei′	Restricted to quantity or number.
	chuk′li	Although these refer rather to quality than quantity, they can be used in either sense. When combined, as is sometimes the case for emphasis, they become *o-ru-i chuk′-li.* Although both have the meaning of much, or very, each is used, according to custom, with particular words, although with no difference of sense; *o-ru*
	o-ru′-i	

		nyets, very heavy; *tyŋg chukli*, very large; *pe ratski orui*, many people are coming; *pe tsosi tsot-tsei*, there are many people there.
how much	be-koŋgs′	
mud	doch′-ka	*Chi-ka*, material.
mute	mĕ,	
nail	u-rats′-kwo	*U-ra+ska*, finger; *kwo*, scale, skin, &c.
naked	sum′-ĕ wu′-ji-ka	Both words are used for bare or naked; but the latter ("empty" *q. v.*) is usually applied to naked children who, according to local custom are yet too small to wear clothing.
to name name	ĭ-kye′ kye	Probably both derived, with ĭ-ki-a′-na, to want, from the same root as *ĭ-kiu*, to call. These three verbs run into each other in conjugation.
narrow	shu+tsi′-la-la	*Shu*, see middle; *tsi-la-la*, small. Anything hollow; also a stream.
	bŭ-sutk′	Anything solid.
navel	mo′+wo	*Knot.*
near	tsi′-net	
	ku-ku′-ni	In place or time.
	ket′-ke	In time only.
neck	ki-li′+kĕ-cha	This *kĕ-cha*, does not seem to be connected with *ki-cha′*, a string or tendon. It occurs again in leg.
necklace	na-mu′+ka	Tiger's teeth.
	pu-li′+ki-cha	Made from shell beads; see *shell* and *string*.
	bi′-wo+ki-cha	Made from beads *q. v.* There are other less common names, all taken from the material

needle	kush	
	di-ka′	Thorn.
negro	tset-tse′+wak	*Tset-tse*, dark ; *wak*, race.
nest	du′+hu	*Du*, bird; *hu*, house.
new	pa′-ni	
night	nĕ-nye′-wi	
nipple	tsu+wo′+bĕ-ta	*Tsu-wo*, breast ; *bĕ-ta′*, point.
no	au	Negation.
	ke	Not.
nobody	ke′+ji	*Ke*, not ; *ji*, who.
noise	ha-lar′	
noon	di′+bĕ-ta	See *midday*.
nose	ji′-kut	
not	ke	
	kam	*A* as in father. Used only as follows—"*kam je bowo′ betse′*" (not I fire prepared). "I have not kindled the fire."
nothing	ke′+ku	*Ke*, not ; *ku*, more.
	shun′-tai	Nothing whatever. Only used for "absolutely nothing."
now	i′-ya	See *here*, and *to-day*.
nuchal lump	ku-li′+duk-wo	*Ku-li*, see neck. The enlarged nuchal ligament caused by carrying heavy loads suspended from the forehead.
numerals		
1	et	
2	but	Impersonal.
	bul	Personal.
	bui	Counting days, future.
	bo	Counting days, past.
3	m-nyat′	Impersonal.
	m-nyal′	Personal.
	m-nyar′	Counting days, future.
	m-nyon′	Counting days, past.
4	keil	
	keng	Counting days, future.
	ka	Counting days, past.
5	skang	
	skan	Counting days, past.

6	terl	
	ter′-i	Counting days.
7	ku′gl	
	ku′gu	Counting days, future.
8	pa′-gl	
	pai	Counting days, future.
	pa	Counting days, past.
9	su-ni′-to	
10	d-bob′	
11	d-bob+ki+et′	*Ki*, more; *et*, one.
12	d-bob+ki+but′	
13	d-bob+ki+m-nyat′	
20	d-bob+but′-juk	*But juk*, twice.
21	d-bob+but′-juk+ki+et	
oil	ki-u′	
old	i-nu′	Old and worn out, or decayed.
	ke′ji-ke	Old person.
on	bĕ-ta′+kin	*Bĕ-ta′* summit; *kin*, region.
once	et′+ĕ-kur	*Et*, one; *e′-kur*, alone.
one, at a time	et+ket′-ke	See *only*.
only	e′-mi	See *alone*.
	ket	*Et+ket*, only one; *but+ket*, only two,
open	ha′-si	
to open	ĭ-šhku+ku′-ka	To uncover a vessel, to open a book; see to cover.
	ĭ-wo′+wa	To open a door; see to shut.
	ĭ-shung+pu′	To spread, to unfold.
	ĭ-pu	Also to strike, to push.
	ĭ-wo+pu′	They sometimes say *ku šhku pu*, literally, "push the door (open)," but *i-wo-wa* is better.
to oppose	iu-mu′-ka	
other	sä-ka′	*Also*,
	hau′-ri	*Different*,
	et′+ĕ-kur	*Once*,
		There is no nearer way of approaching the idea.
otter	ha-wa′	*Lutra Braziliensis?*

out outside	u′+te+kin	*Kin*, see region. *u* is probably from *hu*, house. The expression (literally outside of the house) is applied to the outside of anything.
over	bĕ-ta′+kin	See *on*.
oyster	shuk′-te	
to pack	ĭ-be-ku′	See *to drive, to envelop, to cover*.
package	dli	
pain	dĕ-li′-na	See *to ache*.
to paint	pat′yu	
palm of hand	u-ra′+ptu	*Ptu*, palm or sole; see *foot*.
pantaloons	klu′+yo	*Klu*, leg; see shirt.
part	ek′-sin-e	
to part	ĭ-bra′+tu	*I-tu*, to cut.
to pass	ĭ-ru′+mi	*Mi* (*ĭ-mi′-a*) to go.
pasty	i-tu-wo′	Like dough or stiff mud; see *viscid* and *fluid*.
to pay	pa-ṭu-en′-ke	
pebble	ak′+wo	*Ak*, stone; *wo*, round, lump.
peccary	ka′-sir si-ni	*Dicotyles torquatus*. *D. labiatus*.
penis	ma-lek′ kĕ-be′+wo	Human; see *tail* *Kĕ-be′*, snake; applied to all the lower animals.
people	pe wak wak+i-pa	As individuals, As applied to tribe or race. Collective, thus *sa wak-i-pa*, our people; never *sa-wak*, to distinguish from ant (*tsa+wak*).
perhaps	bru	See *to ignore*.
perpendicular	shke′-ka	See straight.
person	ji ke′-ki	See who; *ke-ji* nobody. Person of consideration, used like *sir*, in English; probably from *ke′-ji-ke* old.
petticoat	ba′-na	The native dress of the women; a cloth tied round the loins and reaching to the knees.

to pick up	ĭ-shtuk	To gather.
	ĭ-ku′kn	To lift.
piece	tak	
pile	ĭ-ra-pa′	A heap.
to pile up	ĭ-ra-pa′+ung	
piled up	ĭ-ra-pa′+na	
to pinch	ĭ-ku-ni-tsu′-wa	
pine apple	a-mu′+wo	
pipe	ca-chim′-ba	A borrowed word found all over Spanish America.
place	ske,	In *place* of; see *equivalent.*
	i-to′	*Place* for a thing.
	koŋ̃g	See *country*; *ima koŋ̃g kye?* "what is this *place* called?"
plain	koŋ̃g+shke′	*Shke*, flat.
to plait	du-ki′,	
to plant,	ĭ-taung′-bo	Seeds.
	ĭ-kyu	Roots.
plantain	kŏ-rub′	
plastic	i-no′-i-no	
to play	ĭ-nuk′	
plaything	ma′-ma	See *flower.*
	nu′-kur	See *metal, money,* and to *to play.*
plenty	o-ru′-i	Much, many.
	shkon′-ten-e	
point	bĕ-ta′	Also summit, top, end.
pointed	bĕ-ta′-ta	
polished	u-ris-u-ris′-i	
possession	cha	See note to *mine.*
pot	ta-be′+ung	*Ta-be′*, iron; see *iron* and *jar.*
to pound	ĭ-wo+tu	
to pour	ĭ-tu′+tsung	To pour out.
	ĭ-tu′	To pour in.
	ĭ-u′	
precipice	ak′+tu	*Ak*, stone, rock.
pregnant	nya′+ye	Human; see *belly.*
	bo′-bo-kye	Lower animals.

to prepare	ĭ-be-ket′-ke	See *ready*.
pretty	boi	See *good*.
price	town′+ske	See *to buy; ske*, value, equivalent.
priest	tsu′-gur	*Ish-tsu*, to sing; a singer.
proof	cha′gu	
to prove	ĭ-cha′-gu.	
to pull	ĭ-kuñg.	
to pull out	ĭ-shuñg′+kuñg	To straighten; to spread out.
pulse	si-wañg′+ki-cha	*Si-wañg*, wind; *ki-cha*, string.
to push	ĭ-pai′-ku	
to put	ĭ-muk′	See *to give*.
to put into	ĭ-u′	See *to pour*.
quarter	ĭ-ju-wa′	Applied only to the quarters of an animal; for a fourth part of an inanimate object, they only say *tak*, a piece.
quick	bet′-ku	Rapid, sudden, to hurry.
	dĕ-re′-re	Applied to a rapid stream.
	bou′-i	Very quick.
rain	kaw′-ni	This word is now in a transition state. *Koñg+li*, the original form (see note on *dust*) is still sometimes, though rarely, used, and is equally understood.
rainbow	kĕ-be′	Snake.
rat	skwe	Also mouse and mole.
ravine	koñg+be-li′-na	
raw	ha′-ki	
to reach	ĭ-ru′mi	In going to a place.
	ĭ-re′-ska	With the hand; always used with *u-ra* (arm, hand); thus "I cannot reach it" *ke je u-ra re-ska*.
ready	on′-a	
	bĕ-ket′-ke	To prepare.
red	mat′-ki	
	mat′-kli	Reddish.
	ma′-ru	Brownish red.

region	kin	*Kin* has a double meaning. It is used thus, *Lari kin* the region, or district of *Lari; dĕ-je kin*, the salt region (the sea). Besides it signifies on, or in, a place or direction; *is kin*, below; *bĕ-ta kin*, on the point or summit of a hill; *nyo-ro kin* on the road.
to remain	on′-te	
remainder	bĕ-ta+on′-te	Bĕ′-ta, see end, point.
	bĕ-ta+tso′+nya	*Tso(et-so-si)* to have, to be.
to remember	ke+hĕn-i-cho	*Ke*, not; see *to forget*.
to resemble	suŋ̂g	To see, to look.
to reside	se′-ne-ke	
to rest	he′-ne-ke	
to return	re′me-li	
ribs	chi-ne′	
ribbed	bŭ-chĕ-no′-noi	
right	boi	Good.
right hand	u-ra+bwa′	*U-ra*, arm; *bwa*, right, in sense of direction or side only.
rim	su-su′-i	
rind	i-kwo′-lit	See *skin, bark*.
ring	shkit′-ke	See *shki*, round.
ripe	ri	
to rise	i-ku′-kn	
river	di+ki-bi′	*Di*, water; *ki-bi*, large.
rivulet	di+la	*La*, diminutive.
road	nyo-ro′	
to roast	ĭ-ku-ke′	
rock	ak	Stone.
to rock	a-lik-a-lik′-e	As a cradle, or a round-bottomed vessel.
to roll	ĭ-wo-be-tru′	See *to twist, to turn, to shake*.
roof	hu+ku	*Hu*, house.
roots	wi′+nyuk	*Nyuk*, rump, butt.
rope	bus′-kr	A twisted, or "laid" rope.
	du′-ki	A plaited rope.
	tsa	A common, roughly made rope, a bark string, or a vine used in tying; see vine.

rotten	ĕ-nu′-nĕ-wa	See *old*.
rough	a-ten-ĕ-ten-e′	
round	shki	Circular.
	wo	Used for anything rounded, like the face, a seed, a lump in the flesh, a rounded hill, the sun, moon, and in the names of various parts of the body.
rump	nyuk	See *butt*, *roots*, *river*, *mouth*.
to run	ĭ-nen-e′	
sacrum	ju′-wo+di-cha	*Ju′-wo*, small of back; *di cha*, bone.
sad	hed-i-a′-na	See *grief*, *sorry*.
saliva	wi′-ri	
salt	dĕ-je′	
sand	tsoñg′+chi-ka	See *beach*, *gravel*, *material*.
sap	wu′-li	This root, probably derived from some allied dialect, is now adopted into Isthmian Spanish as "uli," "hule," etc., for caoutchouc.
savannah	sok	
to save	ĭ-bru′	
to say	ĭ-chu′	
scab	ĭ pash′+kwo	*Kwo*, scale; not *ĭ-pa+skwo* to wash.
to scare	sŭ-wa′+ung	See *to frighten*.
scattered	tski′-tski	
scorpion	bi-che′	
to scrape	i-a-pa′+si-u	Like to scrape the bark from a stick; to scale a fish is *i-kwo′+si-u*.
	ĭ-kru′	To clean a dirty surface.
to scratch	i-bi′-u	
sea	di+dĕ-je′	*Di*, water; *dĕ-je′*, salt.
	dĕ-je+kin	See *region*.
to search	ĭ-ju+lu′	See *to hunt*, *to look for*.
to see	sueñg	
seed	wo′	See *round*.
to sell	ĭ-me′-rir	

to send	ĭ-pat-ku+mi	*I-pat-ku*, to push ; *ĭ-mi-a* to go.
to sew	ĭ-wo+ju+wo	*Wo*, besides round, means in this and similar connections, whole, together, complete or closed. See *to close ; i-ju-wo*, to make, "to make closed," or "to make together."
shadow	si-ri-u′-gur	
to shake	i-wo+ti′-u	A violent motion like shaking dust out of a cloth.
	ĭ-wo͡ŋg+ju	A gentle motion, like leaves in a breeze.
shallow	i-si′	Applied to water ; *di+si* a shallow stream or pond.
	bu-litk′	A shallow vessel, like a pan or dish.
sharp	a-ka′+ta	*A-ka*, tooth, sharp toothed or edged ; like a knife edge.
	bĕ-ta′+ta	Sharp pointed.
to sharpen	a-ka′+ung	
	bĕ-ta′+ung	
she	ye	Also *he*.
shell	jok′se-rɔ	Flat univalves ; *helix*, *cyclostoma*, *helicina*, etc.
	pu-li′	Long univalves ; *melania*, *bulimus*, *glandina*, etc.
	su-ri′	*Donax*.
	sa-ra′	Large bivalves.
shield	so′gur	
shin	taŋ′+wo	
to shine	du-r′u′-ru-i	
	ĭ-lu′+gur	*Lu*, light ; to shine like a fire, to give light.
shirt	pa′+yo	*Pa*, skin, covering ; see pantaloons.
to shoot	i-tu′	To cut, to chop.

short	hu′-ye hu′-shi-a	This was explained to me by the person holding his hands but a few inches apart; saying this was *hu′-ye*; with his hands about a yard apart he said *hu′-shi-a*, while any greater length is *bi-tsing*, long.
shoulder	so′-bri	
shoulder blade	o	See *axe*.
shrimp	so′	
to shut	ĭ-wo+tu′ ĭ-šhku+pa-bĕ-ku′	See to close, to cover, to open.
sick	ki-ri′-na	
side	wo′+su-li u-ra′	Of the body. Right or left hand; *u-ra*, arm.
silence	bi′-nĕ	
similar	he′+kĕ-pi nyi′+ke-pi di-u′-si nyi+šhtsei′	Alike, also, thus. Equal, alike. "Like that." Exactly alike, in speaking
to sing	ĭsh-tsu′	See *priest*.
sister	kut+a′	
sister-in-law	bo′+kut	
skin	i-kwo′-lit pa	Cuticle, bark, scale, nail, feather, &c. Cuticle, surface, or any soft outer envelope.
skull	wo′-ki+dicha	*Wo-ki*, head; *di-cha*, bone
sky	hoiŋ′+kut-tŭ	See note to *country*.
to sleep	kĭ-puk′	
sleepy	kĭ-pu+wet′-ke	
sloping	o-utk′	See beveled.
sloth	sĕ-noiŋ′ se′-ri di′-ra	*Choloepus Hoffmanni*. *Arctopithecus castaniceps*. *Cyclothurus dorsalis*.
slow	en-ai-en-ai′	
small	tsi′-la-la	See *little*.
small of back	tsiŋ-wo	
to smell	la	
to smell good	a-mas-a-mas′ m-nas-m-nas′-i	Like flowers and fluids. Like food.
smoke	shkon-o′	

smooth	ji-ji	Both syllables equally accented. Not necessarily polished.
	jis-jis	
	u-ris-u-ris′-i	Polished.
snail	pu-li′	See shell
	jok′-se-ro	
	ki-pe	Shell-less species.
snake	kĕ-be′	A curious coincidence exists in the fact that in the Island of Santo Domingo, where there are no venomous reptiles, a poisonous plant, retaining its native name, is called by the people *ki-be′*.
to sneeze	chi′-na	
so	i-nyes′	"So, or thus, he says."
	he′-kĕ-pi	Alike, or similar; it is also used in the sense of "do it *so*."
soft	a-ni′-ni-ĕ	Like cloth.
	b-jo′-b-jo	Like a cushion, or soft bread.
soil	i′-juk	Earth; not *ĭ-juk′*, to drink.
sole of foot	klu+ptu	*Klu*, foot; *ptu*, also palm of hand.
solid	me′-ye	
sometimes	mi-kle′	
son	je+la	*Je*, my; *la*, or *la-la*, from *tsi′-la-la* little. Father, mother, son, &c., are always used with either a personal pronoun, or the name of the relative.
son-in-law	na-wa′-ki-ra	
soon	sir′-a-pa	See immediately.
	tsi′-net	Near.
sore	su-me′+wo	Ulcer.
	ki-nuŋ̍g	Proud flesh.
sorry	hed-i-an′-a	See grief, sad.
sour	shku-shku′-i	
to speak	ĭ-shtu	
spirit	bi	See *ghost;* also introductory notes.
	wig′-bru	

to spit	wu-ri+tu+wo′	See *saliva.*
spleen	tak	See *fever.*
to spoil	ĭ-nu′-nĕ	See *old, rotten.*
spotted	kro′-ro	
to spread	ĭ-shuŋ̍g+tsu	Loose objects, as grain, cacao, &c.; also to unroll.
	ĭ-shuŋ̍g+pu	A cloth, &c.; see to open.
spring	jol	Also a cataract.
sprit	su-re′+wo	
spy	i-tut′-kuk	
square	shki-shki′-a	This word applies equally to a triangular or a polygonal surface, and means rather *angular.* There are no specific names for figures of different numbers of sides, the exact shape being designated by such phrases as "four-sided," &c.
	si-chit′-ki-a	A square prism; like a beam; see angle.
to stab	ĭ-tiuŋ̍g′+wa	
to stand	ĭ-mer′-dwo	
star	bek′+wo	
to start	be-te′	
to steal	hog′-bru	
stick	kar	
to stick to	ĭ-ba′-tsa-wa	
sticky	bi-ti-bi-ti′	
to sting	ĭ-tke′-wet	
to stink	o-ru′+ha-ra	*O-ru′-i,* much.
	la+su-ru′-i	*La,* to smell; *su-ru′-i,* bad.
to stir	ĭ-shu+ĭ-kruŋ̍g	*Shu,* see middle; *ĭ-kruŋ̍g* to grasp, to hold.
stone	ak	
stool	krŭ-wa′	See *bench.*
stop	pa-pa′	Second person, imperative, present. This verb is used in no other mood, tense, or person. In all other cases, *kin′-tsu,* to wait, is used.
stout	chi-ka+tyŋ̍g′	*Chi-ka,* material; *tyŋ̍g* big

straight	shke+we′	
to straighten	ĭ-shung′-lu	
to strike	ĭ-pu	To beat.
	ĭ-tu	To strike with the intention of cutting or wounding; see *to chop*, *to shoot*, &c.
string	ki-cha′	
strong	dĕ-re′-re	
to suck	ĭ-ku′+juk	*Ku*, tongue; *ĭ-juk′*, to drink; also to lick.
sudden	bet′-ku	Quick.
sugar	pa′-gl+chi-ka	See sugar cane; *chi-ka*, material.
summit	bĕ-ta′+kin	*Bĕ-ta*, point; *kin* region; the summit of a hill or road.
to summon	ĭ-ki-u′	To call.
sun	di′+wo	
sure	je′-na	See *true*.
to swallow	ĭ-mru′+mi	
sweat	pa+li′-na	See *hot*.
to sweep	ĭ-wush′+kru	See *broom* and *to scrape*.
sweet	bro-broi′	
to swim	a-u′-ku-ri	
to swing	ĭ-ung′-ke-a	
tail	ma-lek′	
to take	ĭ-tsu	
	ĭ-tsu′+me	*Me*, yourself (take from me).
	ĭ-ju′+tsu	*Ju*, auxiliary (go and take.
	ĭ-tsunk′	Take it up.
to talk	ĭ-shtu′	To speak.
tall	tyng′+bru	See large.
tame	hu′+ru	*Hu*, house.
to tangle	ish-chon′-a-ga	
tapir	na-i′	
to taste	ĭ-quash′-tse	
to tear	ĭ-krash′-a-na	Like cloth.
	ĭ-schi′-na-na	To tear open, like splitting a piece of sugar cane with the hands, or tearing open the skin of an orange.
teat	tsu′+wo	

teeth	a-ka′	While other tribes have special names for the molars, the Bri-bris call them *a-ka+di-u′-shent* (back teeth).
temples	wo′+ki+cha	*Wo-ki*, head ; *kĕ-cha*, see leg, neck.
tender	to′-to	See *fragile, weak.*
tendon	ki-cha′	*String.*
testicles	kyak	
that	es′-e	Apparently Spanish, *ese.*
that (is it)	es′-es	" " *eso es.*
then	e′-wa et′-to	Also afterwards.
there	di-ya′ di-ya′+e-ku	"In that direction ;" see *here.*
they	ye′+pa	See *he.*
thick	bu-ri′-ri	
thief	hog′-bru+ru	See to steal.
thigh	tu	
thin	si-bu′-bu-i	
to think	hĕn′+bĕ-ku	See *forget, remember*, and introductory notes.
this	i′-sa hi	Not *e′-se*, that.
thorn	di-ka′	*A-ka*? tooth. Derivatively applied to a needle.
thorns	di-ke′	Plural ; see introductory notes.
thou	be be′-re	*Re*, see note to I.
thrice	m-nyat+juk	
throat	bi-do′-nya	
to throw	ĭ-hu′-juk ĭ-tu	See *to shoot, to pour*, &c.
thumb	u-ra+ska+wong′-wi	See *finger.*
thunder	a-ra′	
thus	he′-kĕ-pi i-nyes′	See *so.*
tick	bur-ir′-i-e	This is one of several specific names for the same insect.
to tickle	se-cho′-ne	
to tie	i-mao′	

tiger	di-ko′-rum	*F. concolor.*
	na-mu′	Generic.
	na-mu+kro′-ro	*F. onca.*
	du-re′grub	*F. onca.*
	se-an′-um	*ditto, black var.*
	išh-tsa+na-mu	*F. pardalis.*
time	nyo-nyo′-ne	Past; it means "a long time ago."
	ĕn-e′-ri-ĕ	Future time, also remote.
tired	shti-ri′-na	
toad	bu-ke′	
tobacco	da-wa′	
toes	klu+rat′-ska	*Klu*, foot; *rat-ska*, see finger.
together	nyi′-ta	See *with.*
	edj′-ka	
	nyi-šhke′	See *even.*
to-morrow	bu-le′	
tongue	ku	
top	bĕ-ta′	See point, end, summit.
top of head	man-e′+bĕ-ta	*Bĕ-ta*, summit.
torch	kirk	
tortoise	kwi	
to touch	i-ku′+wa	
tree	kar	Also stick; see forest, &c.
top of tree	kar+ko′+bĕ-ta	See *tree* and *summit.*
trunk of tree	kar′+ŭ-ku	
tribe	wak	
true	je′-na	In the sense of "yes, that is so."
	maw′-ki	Absolutely; as contradistinguished from false.
truth	maw′-ki	
to turn	ĭ-wo+tru	See to *twist, to roll, to shake.*
ugly	su-ru′-i	See *bad.*
ulcer	su-me′+wo	
uncle	yĕ-nong′	Maternal.
	yĕ-nong+juk	Paternal.
unclean	nya′	Dirty, filthy; see *dung.*
	bu-ku-ru′	In superstition.
under	is′+kin	See *below.*
to understand	išh-tse′-bo	
unlike	hau′-ri	
unripe	ha′-ki	
	pan′+ri	*Ri*, ripe.

to unroll	ĭ-shuŋ̃g+tsu	See *to open, to spread.*
to untie	ĭ-wo′+tsu	
until	ĭa-pan′-a	
to unwind	ĭ-shuŋ̃g′+tsu	See *to unroll.*
up	shke	See straight.
	a-koŋ̃g	
upon	a-koŋ̃g	
	bĕ-ta′+kin	See *point, under,* and *summit.*
upper arm	u-ra′+krob	*U-ra,* arm.
upright	shke′+ka	See *perpendicular.*
to use	ĭ-wa′-tu	
valley	koŋ̃g′+bli	
value	ske	See *equivalent.*
vein	ki-cha′	String.
very	o-ru′-i	See much.
	chuk′-li	See much.
	tu-ru′-ru-i	Applied only to *very* hot water.
vertebra	ko′+wo	
vine	tsa′+ki-cha	*Tsa,* any vine or strip of bark that can be used to tie with; *ki-cha.* a string.
	kar′+ki-cha	*Kar,* wood; generally, one that *cannot* be used to tie with.
viscid	kŭ-nyo′-kŭ-nyo	Like syrup or honey.
voice	or′-ke	
to vomit	cho′+li	*I-cho,* to lose.
to wag	ĭ-wo+tsi′-tsi	Like a dog's tail.
waist	ki-par′	
to wait	ĭ-kin′+tsu	To wait for anything or person.
	ĭ-pan′-a	To wait until another time.
to walk	ĭ-shku′	
to want	ĭ-ki-a′-na	See *to call, to name.*
warm	ba	See *hot.*
to wash	ĭ-skwo′	
wasp	bu-kra′	
water	di	
watery	di+se-re′-re	
wax	bur′+nya	*Bur,* bee; *nya,* dung.
we	sa	

weak	to′-to to-toi′	See *tender; fragile.*
well	ble boi	Noun. Adjective and adverb; good.
to weep	ma-iu′	
wet	nu-ne′-ga tsĕ-bat′-tsĕ-ba	The person, as in a rain. See green; applied to inanimate objects.
what	i ed-i′ wes ji	"What is it," or "what is the matter." "What did you say?" Personal; who.
when	mi′-ka	
where	weńg we′-du	"Where is ——?" Used in a sentence. Used alone.
whisper	sa′-sa	
whistle	šhka′-kuńg	*Ka* (*a-ka*) the teeth?
white	su-ru′-ru-i	Also light colored.
who	ji	
whole	wan′-yi	Entire.
why	iub i-kuen′-ke in′-u-i	Used alone, or at the beginning of a sentence, *i-kuen′-ke* means "that is the reason," as well as being used interrogatively. Used alone.
wide	shu+tyńg′	See *middle, narrow,* and *large.*
wife	je+ra′-kur	See *woman* and *son.*
wild	ka+nyi′+ru	See tame; *ka* (*kar*) tree (forest); *nyi,* together.
wind	si-wańg′	
wing	i-pik′	
to wipe	ĭ-pa+kru	See *to scrape.*
with	ta wa	Accompanying. By means of; *i-wa?,* "what with?"
woman	ĕ-ra′-kur	
wood	kar	See *tree, stick.*
to work	ka-nĕ′-bruk	
worm	nya+bus′-ĕri nya′+wak	*Lumbricus; nya,* dung.

to wrap	ĭ-bĕ-ku′-wa	
to wring	ĭ-wo+bĕ-tru′	See to roll.
wrinkled	jŭ-ku-nu-jŭ-ku-nu′	
wrist	u-ra+wo′+bak	
year	da-was′	The year is counted by the dry seasons when the flower stalks of the river cane are ripe and fit to cut for arrow shafts.
yellow	tski-ri′-ri	Bright yellow.
	dŭ-ko′-lum	Brownish yellow.
yes	he	Synonymous; *hĕ* is most commonly used.
	tu	
yesterday	chi-ki′	
you	ha	
young	pu′-pu	
yourself	me	Only used in compounds; see note on pronouns.

CHAPTER III.

COMPARATIVE VOCABULARY OF THE CABECAR, TIRIBI, AND TERRABA LANGUAGES OF SOUTHERN COSTA RICA.

English.	Cabecar of Estrella River.	Cabecar of Coen River.*	Tiribi.	Terraba.	Brun-ka (called by the Spaniards Boruca).
to ache				ban	sa-o-ra
to adhere				to-mok′	
afraid	su-wa′-na	———	ban-kret′	ko-ban-kret′	kong′-li
afterwards				dun′-i-ha	ne-nyi′
again	i-shu′-ne	ska-shu′	roz-o′-bi	o-ro-roi	e′-je
against				krŭ-boi′	
ahead			zhug′+ung		
to aim				doz′-ung	
air	kong+shan-ka	kong+shung	kok′+zeng	kon͡g-mosh′-ko	
alike				lin-ko-yos′-o-sa	do-she-ri′
alive	ksi	———	si	se	
all	be′-na	———	pir′-kru	tue′	o-ge′
alligator	do-rok′	———	ku	———	ku′-u
alone	e′-kra-bu	e′-kra-i	tok′-sa	———	i-le-shi′
alongside	kot-ke′-mi	———	a-sor-go′		
also				no′-ma	mo-reng′-li
angry				yir′-ke	dre-ha′-lan
ankle	wir-in′-a-kru	———	ton′-kwo	ko-gi-o′	
ant	ksa′+wak	———	sum′-gwo	son′-gwo	jak
anteater (large)	ur-i′	———	shu-go′	———	

* To avoid unnecessary repetition, where the same word occurs in the two dialects of Cabecar, or is the same in the Tiribi and Terraba, a ——— only is used.

English.	Cabecar of Estrella River.	Cabecar of Coen River.	Tiribi.	Terraba.	Brun-ka.
anteater (small)	sa′-sa-ra	———			
any	i-hue′-na	———			
to arise				yir′-ke	
arm	u-ra′	———	ork′-wo	or-og′-o-dok	ju-re′
to arrive	sri′-ska	———	o′-tong		
arrow	u-ka′-wŭ	———	su-re′	———	tun-kas′-a
ashes	mnu′-tu	———	prun′-shuk	prun′-sho	brung
to ask	i-cha-gu′	i-cha-ge′	kag-ra-koz′+ung		tek-shik′
aunt	wai′-bu	———	me′-d-bog-wo	tia (Spanish)	
awake				pe-zhem′-e	
axe				o	
back	shĕ-be′	———	kok-so′	———	ching-kwa′
small of back	tsi-wŏ′	———	si-yek′		a-du-ran′
backwards				i-le′-kung	a-che′
bad	se-ru-i′	———	oi′	so-oi′	sa-i-jen′
bag	ha-mĕ′-tu	———	hru	———	
banana	chi-mu′	———	kei+bing	bin+si′-gua	bri′-dwa
bare	wu′-ji-ka	———	kwor		but-sa-she′
bark (of tree)	kar′+kwo	———	kar′+kwo	kor′+kwo-ta	krang′+kwas
basket	ku	———	h-nu′		ko-kra
bat	d-kur′	———	i-gur′-gwo	i-gur′	kŭsh-tsi′
to bathe	bo-ku′	———	we		
beach				la-go′	
bead	sa-wa-wu′	sa-wi′-wu	o′-bri	o′-bri-kro	
beak of bird	i-ka du+ka	——— ———	sin′-wa+ko-wo	———	ka-sa

beard	kar′-gu	————	zong	————	ošh′-tsi
beast	bi	————	no generic word	no generic word	
bed	kă-pu′-gru	kong	bu′-kru	bu-kru′ i-ong′	
bee	bur+wak	————	or	————	
before	mi-ga′-che	————	bom′-gung	————	
behind	bĕ-ta′+ha-mi	————	ir′-ung		a-wah′-i-gi
belly	nya′+wi	————	bo-wo′	————	ku′-a
below				tush′-ko	
belt				kro-ten′-za	suamp′-ka
bench	kru′-wa	————	kruk	kru	te′-kra
better	boe′-si	————	kob′+ko	kob′-i	
between	shas′-ka	shus′-ka	jig′-rai	zig′-ro	
bird	du	————	sin′-wa	sen′-o-wa	du-tsut′
to bite	i-gu-tu′	————	tun-ez′+ung	we′-a	tu′-li
bitter	b-chin′-a	————	kek-teng′		
black	do-ro′-na	————	zi	sok′-si-ĕ	tu-li-nut′
blade				druñg′-wa	
blind				bo-kwoi-zhem′	tu-ĕt′
blood	pi	————		sring	ji-bi′
to blow	wu′-kwa	————	bu-kwaz′+ong	ba-kwoz -ung	i-bu-hu-gran′
blow-gun	mok′-kur	————	mok′-ru		
blue	siu	————	ding-ding′-eh	ding-ding′-ĕh	wa-a-gat′
blunt	kai+hu-rin′-a-wa	————	beg-jim′-ĕ		
body	wa′-ki	wa-ge′	i-do′	i-dob′	
bold	I-han′-ĕ	————			
bone	di-cha′	————	d-bo′-gro	————	det-kra′
both	bor+ki′	————			

English.	Cabecar of Estrella River.	Cabecar of Coen River.	Tiribi.	Terraba.	Brun-ka.
bow	u-ka′+bĕ-ta	———			
boy	ber+je′	har-a′	du-met′+wa	kwa-zit′	jas-rok
branch (of tree)	kar′+u-ra	———	kor′+ko-wo		
to break	i-pan-o′-wa	———	toz′-ung		
breast	her′+bĕ-ta	———	wor-bu′	———	bi-dran′
breast (of woman)	tsu	———	nok′-a	nok′-o	i-ka′
breech-cloth	ki-par′-wo	———	shwong+kin′-go	shwong-king′	
bright	d-ra′-na	kan-yi-na′	kro′-zhing	———	
to bring	tsum′-be-te	———	tek+suz′+ong		
broad				ba-mi-on′-so	
broom				shto-ko′-kra	
brother	ser′-a	ja-mi′	shi		
brother-in-law	shoo-wa	———	bau′	———	
bug	*nya′-hru	———	*guk′-sha		
bundle				pfon-u′	
to bury	i-tu-bi-u′-wa	———	pnoz′-ong	pfrou′-zo	
bush	kar+tsi′-lash-tu	———			
bush dog†	rob-gu′	———		o-ru-bu-gu′	
butterfly	kwa	———	kwong′-wo	———	kwašh′-ka
to buy				tun-ez′-ung	
cacao	tsi-ru′	———	kau	ko	kao
calabash	d-ka′	———	yi-guk′	———	jun′-kra
cane (sugar)	pash-tu′	———	se-ror′+bo	———	bah+je-ra′

* These words are probably specific. The genius of this group of languages is not to have generic words like bug, beast, palm, &c; though there are some exceptions, like bird, butterfly, &c.

† For the technical names of these animals, see the Bri-bri vocabulary.

cane (river)	u-ka′-gru	u-kwa′-gru	se-ror′+gro	s-ro′-gro	bah+kra′
caoutchouc				sŭ-ru′	
to carry	tsum′-mi	———	hek+suz′+ong		
cataract				her-pig′-to	
catarrh	to	———	tau′		
to catch				shaz′-ung	
to cheat	i-hag′-bra	i-kon′-ju-wa	yab-goz′+ung		
cheek	hog-o-tu′	———	kwog′-do	kwog′-ro	pshu-gran′
chicha	bro	———	o	———	jĭ-wo′
chief	bo-ru′	———	pu-ru′	———	
child	jo-ba′	jo-ba-ra′	wa	ang′-wa	
chin	ska′-jua	———	o-ro′	———	ksha′-di
to chop	i-bi-ku′-hŭ	———		zog′-ung	
clean	ma-nen-ai′-re	man-em-en-e′		krung′-zo	trut′-ka
cloth (cotton)	sa-wa′+ba-gna	sa-wa′	shkwe′+shwong	shkwe′+bor-shwong	
" (bark)	dŭ-tsi′	———	keb′+kwo	———	
cloud	mo	———	pong	———	bok
coal (of fire)	ji-ko′+wa	ji-ko+wo′	yuk+kur′-kwa	kur′-gra	
cold	tse′-na	———	smo	sa-mo′	tsa′
color	ia-wa-kir′		kro-zher′-ba		
comb		i-aï-wa-gir′		kun′-chi	kash
come	hi′-ga	———	pa-teg′-ŭn	———	
to complete				ton-oi′	
coon	si-rak′	———		si-luk	
corn (maize)	i-kwo′	———	ep	———	kup
corpse	i-shen-a′-wa	shin′-a-wa	shin′-mo	———	
cotton	su-wi′+ji-ku	———	shkwi	shwke′-sho	

English.	Cabecar of Estrella River.	Cabecar of Coen River.	Tiribi.	Terraba.	Brun-ka.
cough	to	———	tau	———	
to cough	kor′-har	kor′-her	shtenz′+ung		
to count	kansh′-ta-wa	———	kok-shtoz′+ung		
country*	kong	———	kok	kosh′-ko	kak
cousin	ta-ra′	———	shtob		
to cover	i-ki′-tu-wa	———	kim-yoz′-ong	kin-yoz′-ung	
crab	ju-wi′	———	ye-beg′-wo	———	
crazy	ri-na′-ka	———	skwĕ	———	
to cry	mi-o′	———	so-loi′-wi		
to cut	i-tu′	———	zoz′-ung	———	tsa-a-ran′
to dance	b-klu+tu′	———	zron	———	kwi-gri′
dark	stu-i′-na	———			
daughter	ba′+bu-si	———	wa′+wa-re	———	
day	kan-yi-na′	kan-yi-na′-wa	d-ba′	da-boi′	kak′+a-ba-ra
to-day	hir	———	er′-i	———	cha
to-morrow	bu-ri′-ri	———	i-bong′	i-bon′-a-ga	sek
day (after to-morrow)	boi-ki′	———	kun-ma′	kur+ma′	bwek
third day future				mi-an+ma′	mang-ek′
fourth day future				kin+ma′	
fifth day future				shkin+ma′	
yesterday	jĕ-ki	———	kub′-kĕ	kub-kesh′-ko	bi-ik′
day (before yesterday)	bo-ri′	bo-kri′	pong-wo′	pon͡g-wosh′-ko	ki-bi+buk′
dead	dŭ-wa′-wa	———	ke-tong′	———	košht′-ka
deep (water)	di-kru+tyng′-ru	di-kru+tyn͡g′-bru	i-rong′		
deer (large)	mno-dŭ-bi′	———	prun′-mi	shu-ring′	su-tu-rik′

* In the same wide sense as in Bri-bri.

deer (small)	do-ĕ′	———	shu-ring′	shu-ring′+ma	bušh
to depart				to′-to	
devil	bi	———	au	auh	kag-bru′
dew	mo′+ri-u	———	tom-bor′-ia		
to die			ba-ke′-to		
different	hau′-ri	———	o′-bri	ba-bok′-so	bu-i-shi′
to dig	i-biu′-ga	———	koz′+ung		
direction	wo′-mo	———	jou′-re	yow′-re	
dirt	i′-shku	———	wri-wri′-a		
to dive	b-tsat-ku′	———			
doctor	ha-wa′	———	i-bi′	———	
dog				shi′-ti	aušh
to drink	i-ju′	———	i-oz′-ong	———	i-jang′
drop	i-wo′+riu	———	si-ra′		
drum	sŭ-bak′	———	zhung	———	
dry	si′-na	———	i-dog′-i-do	i-dog-roi′	tsen′-ka
dust					ta-bruñg
eagle	sar′+po	———	do+pung′	———	
ear	zgo-ku′	kwush′-ki	kwong′-wo	kwong′-wa	kwa′-ga
early				ko-o-bi′-ta	
earth (soil)	hi′-zhuk	hi′-zhku	krung	krung′-sho	tap
earthquake	i	———	yo	yo-yan′	
to eat	jĕ-ka′-gri	jĕ-ku′	i-e′	———	ja-ă-de′
eddy	di+ha-ra-mi′	di′+men-e	hi-rung′	pŏ-rung′	
egg	i-si′-a	———	sen′-wa+wa	———	kup
either	mĕ-ne′	———			
elbow	u-ra+o′-gu-chi	———			chušh-che′-wi

English.	Cabecar of Estrella River.	Cabecar of Coen River.	Tiribi.	Terraba.	Brun-ka.
empty	wu'ji-ka	———	i-ro-ri'	i-ro-re'	
end	i-bĕ-ta'	———	kok+shur'-bo		
ended				fir'-kru	
enemy	sĕ-na-ma'-ru	bor-gi'	mor-i-mos'-kwo		
enough	wir'-u	er-u'	kwont'-soi	i-ont'-so	
evening	tsa'-na	tsan'-li	kok+sing'-ĕ	———	
every	ben'-a	se-hen'	pir'-gru		
eye	wo'-bra	———	bok'-wa	———	kai'-ish
face	wo'	———	bok-woi'	bok-wo'	kai'-ish
to fall	i-han'-a	i-han-a-te'	ro-noi'	bo-go-noi'	tru-ŭ-lin'
family	jai'-wa	———	pei'-ga	wai-you'-sa	
far	ka-mi'-mi	———	krong'-e	fo-lai'	ka-wi-gri'
father	i-ji'	ji	kok	———	je-bet
father-in-law	dŭ-bai'	———	ke'-gi	———	
fat (grease)	or'-i	ur	kio'-yo	———	i-bu'
" (animal)				sho-shoi'	
fear				ko-ban-kret'	
feather	i'-ku'	———	kor'-ga	———	ka
to feel	pa-su'	———			
female					i-ra-matk'
fever	kro-na-bi-te'	———	b-gun'	swo-ro'	che
few					ble-a'-dri
to fight	nyak+pu	———	ing'-kwi	i-no-kwe'	
finger	u-ra'+sku	———	sak-wo'	sak'-wo	ku'-skwa
fire	jĭ-ko'	———	yuk	———	ji'-kra
fire-fly			skon'-kwa	skon-kwa'	ki-us'

first	suk′-u-tu	———	bom′-gung		
fish	mi-ma′	———	ma′	———	ung
fish scale	ni-ma′+kwo	———	ma+zre′-kwa	ma+kwo′-ta	
flat	shpat′-ke	———	beg′-ĕ	———	
flea	d-ki′	———	kiung	———	chik
floor	har′-ka	hu+ha′	u+pkwe′-ru	u-i′-ro	
flower	kar+wus′-kwa	———	kor+i-a′-gru	kol′-ong	krang+sret
fly	shi′-bu	———	ji-wir′-wa	———	srung
fog	mo	———	pong	———	
to follow			ir′-gu		
food	jĕ-ku′	———	dli	———	
foot	kru+kwe′	———	shkor′-mo	shkon′-mo	kras′+kwa
forehead					wa-tŭsh′
foreigner	jĕ-ku′-sŭ-wa	———	po-las′-o	fo-las′-o	
forest	kar′+ga	———	kor′+go-rui	krosh′-ko	
free			tok′-sai	———	
friend	her′-bui	———	pei	pfei	
frog	bur′-bi	———	ŏ-rung′		
tree-frog	d-cha′-bu-kwi	bu-kwi′	knos	kro-wem′	
from			i-res′		
full	tŭ-ri′	———	tu′-nai	ta-bo-tu′-nai	kut-ka′-li
to gather	nya′-ska	———	sha-ras′-o		
ghost					i-wik′
girl	bu-si′*	a-la-bu-si′	wa+wa-re′	———	i-ra-matk′
	je-ba′*	———			
to give	i-mak′	———	twoz′+ung		
glad			wo-ko′bi		

* Same distinction of age as in Bri-bri

English.	Cabecar of Estrella River.	Cabecar of Coen River.	Tiribi.	Terraba.	Brun-ka.
to gnaw			po-we′-a		
to go	shku	———	pan-o′-ma		
God	si-bu′	———	zi-bo′	zŭ-bo′	si′-bŭh
good	boe′	boi′	kob′-e	kob′-soi kob′-ĕ	mo-reng′-ri
grandfather	ta′-chi	———	bog-un′	———	
grandmother	ho-jĕ-ku′	———	ter	———	
grass	ta′-tsik	———	jit-sho	kro′-sho	
green	spa	spa-na	ke-song′	ke-song′-ĕ	
to grind			zguiz′+ung	a-we′	
to grow			kun	———	
guatuso				shku-re′	chešht
gun	mok′-kur	———	krik	———	bot
hair	to-kung-gu′	———	kog′-zn	kong′-zn	sišh′-ka
" of body				zo	shi
half	mos′-ka	———	wen-zon′	wor-bish′-ko	išh-ta′
to hallo	m-han-o	———			
hammock	ki-pu′	———	po′-gro		kung
hand	u-ra′	———	ork′-wo	———	ju-re′
back of hand	u-ra′+shi-bi	———	ork-wo+king′		
palm of hand	u-ra+ktu′	———	ork-wo+kwo′-broi		
handle	i′-ka-ta	———	krong	ba-sor′-ko	
to hang	i-kar′-mi	———	priz′-kom-o		
hard	d-re′-re	———	kong′-ko	kang′-kwe	
to have	krir	———			
hawk	pung	———	u-re′+pung	pung	sung

he	hé	———	we	kwe	i+a-bi′
head	dzĕ-kung	———	kog′-o	———	sa-gra′
head of tree	kar′+u-ra	———	kor′+de-woi-rung		
to hear	his′-ka	———	kuz′+ung	ko-kuz′-ung	
heart					kwi-sišh
heat	ba	bar	bol-o′	kli-kli′-a	ji+ong′
to help			kim-toz′+ung		
here	is′-ka	———	husk′-ko	ir-ish′-ko	we-eh′
high	hu-i′-ne	kong+shu′-ki	kok′+shko	kok+shko′-i	ašht-kar-e′
hill	kong+tsu′	———	drub	———	kak-tušht′
to hold	i-kru′-ku	i-kru′	shaz′+ung		
hollow	har	———			
honey	bur	———	or	or′+di-o	but+cha
horn	i-du-ra′	———	su		
house	hu	———	u	———	uh
how	m-ne′-kĕ-pi	———	so′-je-ra	zhi′-ri-a	
husband	(hĕ+)ji′-ji	———	(bor+)do-met′	(bor+)do-ben′	
hunger	bĕ-chi′-na-te	ka′-gre	pli′-do		
I	jis	———	ta	———	a+da-bi′
idle	bi-ki	———	pag-je′-me		
iguana	bo′-a	ba	wong	fwang	ă-lit′
inside	hi′-na	———	ir′-or-e	ir-osh′-ko	
intestine	nya	———	jang′-ko-gru	zhang	su-a′
iron	ta-be′-ri+ji-ka	ta-be′+ji-ka			
jar	hung	ung	zbi	———	
jaw	kab-sha′	———	o-ro′	———	
jigger	d-ki′+tsin-la	———	kiung′-wo	———	
juice	i-diu′	———	di-o′	———	cha

English.	Cabecar of Estrella River.	Cabecar of Coen River.	Tiribi.	Terraba	Brun-ka.
just			so-kob′-so		
knee	k-chu′-wu	———	ko-kwo′	ku-wă′	
knife	ta-be′-ri+je-ba	———	su-gro′	drung	man-kra′
knot	i-wo′-moa	———	ki-bosh′-kwe	———	
to know	hu-nyer′	che-mi′	mi-dep	mi-der′-a	
language	suk-tu′	———			
large	kŭ-bi+bri-wi′	———	tn-e′	kwon-e′	
very large			kiz-bong′-ĕ		
last	shin′-a-wa	———	jam-o′		ok-sha-re′
late	ka-mas′-kra	tsan′-li	kok+sing′-e	———	
to laugh	m-han-ya′	———	har		
lazy	bi-ki	———	pag-ji-me	kar-a-gung′-e	king′-shu
leaf (of tree)	kar+gu′	———	kar+kor′-gu	kor-o′-ga	krang′+ka
" (broad)	sik	———		zor′-go	
lean	j-kai′-bŭ				
to leave			ber-i-oz+ung		
left hand	shu-rĕ′	———	mir′-e	———	
leg	kru+kra-be	———		kwos-bo	
lemon	ash′-ua	———	I-gen-moh′		
to lend	pei′-te	———	poz-kwoz′+ung	———	
level	shpat′-ke	———			
to lie	b-kan-ju′-wa	———	nyor′-ke	———	ka-tu-a-ri
to lie down	m-he-bĕ-kru-wa	———	tush′-ko	bu+tush′-ko	ja-ung
lid	i-kush′-tu-gru	———	bong-za′-kru		
to lift	I-bĕ-tsu′-kn	———	po-yo′-zu	po-yong′-zo	
lightning	kong+wo+hor′-kn	———	zhgu-ring′	zhu-ring′	ji′-kra

lips	ko′-kwu	————	kap′-kwo	————	
to listen	i-ken-su′	————	kuz′+ong	ko-kuz′-ung	
little	tsi′-nĕ-kra	————	ti′-ra	so-ti′-ra	i-sta-mu′-ra
liver	her	————	wŏ	wo	kok
long	kar-kwe′	b-tsi′		bu	
to look	sŭ-wa′	i-sung′	i-zung′		wa-izh′-da
to loose	i-kuk′+tu-wa	————	kŏngz′+ung		
to lose	i-kit′-sen-a	————	hen-oi′	————	a-ring′-ra
louse	kung	————	————	————	
lump	wo-wut-ser-e′	————	zo-i-ring′	kwo-i-ring′-soi	
lungs	jo	————			
macaw (green)	kwa+si-an′-e	pa	yĕ-mos′+kwong	————	
" (red)	kwa+mat′-ka	ku-kwa′	kus′+kwong	kish′-kwong	
maggot	d-chun′-ya		shto′	————	
to make	i-jo-wŭ′		she-ri-oz′+ung	sho-ri-oz′-ung	
male					kong+ad′ra
man	hĕ-ji-ji′	wi′-pa	dŭ-met′	do-ben′	kong+roh′
many	o-ru-i′	————	et′-o	yon′-soi	et-sušh-ta′-ri
how many?					bi-ik′
mark			i-ya′		
marsh	do-ri′	————	krung′-sho	————	
meat	jĕ-ku′+gru	jĕ-ke′	sing	dŭ-li	i-u-ran
medicine	buk′-pu-ri	k-pu′-li	du-ro′	————	
to mend	i-wo-yŭ′	————	yĕ-woz′+ung		
middle	shas′-ka	shus′-ka	wor-be′	wor-be′-shko	išh′-ta
midnight	nĕ-nye′	kong+shong-shong′	kog-rong′-ĕ	ko-i-rong′-i	kag+išh-ta
milk	tsu′+diu	————	nau′+ri-o	————	tur-i-ka′

English.	Cabecar of Estrella River.	Cabecar of Coen River.	Tiribi.	Terraba.	Brun-ka.
mine				to-nya′	a-rek′
monkey (red)	sar+mat′-ka	———	du′-i+go	do	noŋ̍g
" (howler)	d-ke′	———	bib′+go	bib	u′-li
" (white face)	kuk	———	yai′+go	———	ok
mouth				mok+ra-ra′	
moon	to-ru′	tu-ru′	mŏk	mok	tĕ-be′
more	i-ki′	———	o′-bi		
morning	si-nyi′-ra	———	kok+shrung′-to	kok+shrung′	
mosquito	di-kri′	———	kwis′-king	kwis′-kwing	srun-sit
mother	mi	———	meh	———	ba′-bi
mother-in-law	jak	———	aim	———	
mouse					kwi
mouth	ko′-kwu	ku′-a	kam′-o	———	kas′-a
mouth of river				di+sor′-go	
much	bi-ku′	———	et′-o	yon′-so	
mud	do′-ri	do′+ji-ka			so′-ra
nail (finger)	u-ra+sku+sho′-kwe	———	sak-wo+drung′-yo	———	drig′-i
narrow	si-ma′-na	———	pro-tir′-a	———	ku-ha′-dri
navel	mo′+wo	———	tu′-wa	tu′-woŋ̍g	
near	ko-ku′-na	———	sosh′-ku	———	ek-chish′-ĕ
neck	ku-ri′+ki-cha	———	kring′-dok	———	ing-sa′
necklace	ku-ri′	———	bra		
night	nĕ-nye′	———	shke	———	big-at′
nipple					ka
no	kai	———	je′-mĕ	zhe′-mi	
noise	ko′-ju-gĕ	———	tu-ɛ-et′-o	i-rong-ke′	kshis′-ka

noon	mo′-ki	———	dlo-drub		kag+i-bušh′-ta
nose	jik	———	ne′-kwo	———	kshis′-ka
not	kai	———	zham′-ko	zhe′-mi	
now	hir	———	er′-i	———	cha
numerals					
1	et′-ku	———	kra-ra′	kra′-ra	et-sik
2	bot′-ku	———	pug′-da	kra′-bu	bug
3	m-nyar′	m-nyat′-ka	mya′-re	kra-mi-a′	mang
4	kier	kil	p-kegu′-de	kra-bŭ-king′	bašh′-kan
5	sker′a	———	shkegn′-de	kra-shking′	kšhi-skan′
6	ter′-lu	———	ter′-de	kra-ter′	tesh′-an
7	kul	———	kog′-ŭ-de	kra-kok′	kušhk
8	pagl	———	kwog′-ŭ-de	kra-kwong′	ošh-tan
9	te-ner′-lu	———	shkow′-ŭ-de	kra-shkap′	
10	d-bom′	———	dwow′-ŭ-de	kra-ra-wab′	
11	d-bom+et′+ku	———	king-shu+kra′	king-sho+kra′-ra	
12	d-bom+bot′+ku	———	king-shu+pok′	king-sho+kra-bu′	
13			king-shu+mya′	king-sho+kra-mi-a′	
14			king-shu+p-kegn′	king-sho+kra-bŭ-king′	
20			dwow-ŭ+pug′-da	sag+puk′	
30				sag+mi-a′	
oil	ki-u′	———	ki-o′	———	
old (thing)	i-ken′-a-wa	———	ke-ge′	zan-fe′	so-gro′
" (person)	i-ken′-a-wa	———	yi-no+ke-ge′	zan-fe′	
on			hong	č-li′	
once				fra-ra′-soi	
other					e′-je

English.	Cabecar of Estrella River.	Cabecar of Coen River.	Tribi.	Terraba.	Brun-ka.
otter	di′-hu-a	———	won-yuk′	wan-yŭ′	
our			shi′-ya		
out	i-we′-ten-ŭ-wa	shi-bi′-ga	kok′+su	hu′-ga	
outside	wi′-tu-ki	———	kok′+sur-e	hu′-ga	
over	king′-ga	———	kin′-go		
to own			toi		
package	dŭ-li′	———	shwong′+i-do	d-bok′-tan	ets-ong′
pain	di-ka′	di-li′-na	du-re′	ban	sa-o-ra
peccary (wary)	sir-bi′	———	shi-ri′	———	kra-mi-shuk
" (small sp.)	kas′-ri	kas-i-ri′	shtuk′-o	———	si-ni′
piece	i-wu-ku′	i-wu′-gi-tu	ba-ja-mo′	bo-kwa-ra′	
pile	i-dŭ-pan′-a	———	drub-par′-a		
to pinch	i-bĕ-tsu′	———	shoz-goz′+ung	———	
pine-apple	ka-ru-ru′-bui	ha-mu′-wa	pong′-wa	———	bwat
plantain	kru-bi′	———	i-bing′	———	mwa
point	i-bĕ-ta′	———	d-woi-rung′	d-bor-ong′	i-dru′
pot	ta-be′+wi	ta-be′+ung	droz′-bi		kwa-le′
precipice	hak+en′-a	———	i-geng′	i-geng′ / skin	
priest	ksu′-gru	———	tang′ra		
to pull	si-ku′	si-gu′	shiz′+ung	———	
to push	i-nya′-tu-wa	pat-ku′-ju-mi	poz-rez′+ung	———	
quarter	i-ju-wa′	———	ba-bog′-yu	bob-wo-king′-de	
quick	ho-ru′-si	———	mal-ish′-tĕ	mal-e′	do-do′
quiet	kai-wa-shu′-ya	———	king′-e		
rain	kan+i′	———	shu-nyo′	shu-nyoñg′-wa	jo

rainbow	shko-ba′	———	dŭn		
raw					tašh-ka
ready	bi-ka′	b-tsi′	ta-pid′-zung		
red	mat′-ka	———	sri-zrin′	kro-sri-zri-ren′-e	kru-bat′
reddish	b-tse′-na	———		sri-ren	
region	sar′-as	kin	kosh′-ko	———	
to rest	he-ru′	———	wosh′-ti	wosh′-to	
to return	re′-mi	bra′-ni		zwor′-kwoz-ung	
rib				zhgring	
ribs	pre′	———	sheng′-ro	zhgring′-ro (special plur.)	
right hand	mo′-ki	———	kil-e′		
ripe	uri′-ru	———	kwi	———	brot-ka′-li
to rise	ku′-kn	———	shwo′-zu*	———*	
river	di-kru+e-na	di-kru+tyng′	di-kes′	———	di+kak′
road	nya′-ra	———	ir′-o-bo	———	neŋ-kra
roof	hu′+tsang	———	ur+bo	———	
roots of tree	kar′+gi-cha	———	kor′+su-wo	kor+sreng′	kshas
rope	ksa	———	kyuŋ		
rough	pa-nen′-e-ir-u	pa-nen′-e	ŏ-nos′-teng		
round	bri′-na		ki-ring′-ĕ		phi-gi-dat
to run	b-ton-o′	bi-ton′-u-mi	ti-ti-ĕh′	———	
sad				woi′-di	
saliva	kus′-kwu	———	trung	———	
salt	dĕ-ji′	———	drung	———	ki
sand	ksoŋ	———	ĕra-sho′	———	up
sap	i-di-kli′	kar′+diu	kor′+di-o	———	
to say	i-shu′	———	o-ros′	tre	

* Imperative singular.

English.	Cabecar of Estrella River.	Cabecar of Coen River.	Tiribi.	Terraba.	Brun-ka.
fish-scale	ni-ma′+kwo	———	ma+zre′-kwa	ma+kwo′-ta	
to scatter	sho-ti-a-wa-mi	tu-ru-mi′	zhduz′+ung		
scorpion	bi-che′	———	di-ye′	———	
to scratch	hen-biu′	biu	zhguz′+ung	———	
sea	dĕ-je′	———	drung	drung′+shko	ki
to see	sŭ-wa′	———			
seed	kar+wu′	———	kor′+kwo-wo	———	
to send			i′-ri-os	i-ti e′-ba	
to sew				sez′-ung	
shadow	wig′-ra	———	ya′-gro	sen′-te	ka-wik′
to shake	i-wuk-bu′	———	yoz′-ung	———	
shallow	pre′-na	pre′-rĕ	ir-o-ti′-ra	———	
sharp	i-wu-ku′	a-ka′+ta	su-ret-eng′	(edge) peg-you′-soi (point) su-ret-eng′-e	
she	he	———	we	kwe	
shell (bivalve)	su-ri′	———	wu-rir′-kwo shung	(murex) flin′-kwa dŭ-ram′-kwa	
shield	so′-gru	———	sob′-kwo		
ship	kra-be′	———	shkon′-gro		
to-shoot	i-tiu′	———	io-roz′-ong	———	
short			kwo-tir′-a	———	
shoulder	ko′-ka	———	d-wob′-dok		
shrimp	sok	———	kuz′-gwo	———	
sick	kri-na′-wa	———	sur-o-eh′	sur-o′	che-at′
similar	he′-kĕ-pi	———	en′-i-yŭ	sog-bak-teng′-e	i-dosh-ĕ-re′
to sing	bk-su′	———	toz′-ung	———	

to sink	i-wo-tun-a	———	piz′+ung		
sister	ko-ta′	———	dor	———	
sister-in-law	shdo-bu′	———	kak	———	
skin	kwo	———	kwo′-ta	———	kwas-kwa′
woman's skirt	ba′-na	———	shwom′+zring		
skull	tsu-ko+du-chi′	dze-kung+du-chi′	ka′-dre-a	kog-wo′+dŭ-bo	
sky	du-ra′-bru	———	kob′-kwo	kom-oug′	
to sleep	sku-ri′-na	i-skwu′	poz′-ung	———	kap
sloth (brown)	si-na′-si	———	sho-rong′	———	
" (gray)	se′-ri-a	———	ki-a′	———	
" (little)	di-klu′-ji-ba	———	suz-bo′	———	
slow	hen′-a	———	wor′-a	———	ŭ-wa-ta′
small	tsi′-nĕ-kra	———	tĭ′-ra	so-tir′-a-wa	i-sta-mu′-ra
to smell	ha-rar′-ge	———	i-ro′-shis		
smoke	shkon-ĕ′	shkon-o′	nyo′	———	ji-ĭ-ja′
smooth	jes′-na	je	tu-it′		
snail	*bu-ri	———	*pu-le′+na-kwa	shku′-ra-kwo	
" shell	*jok′-sĕ-ro	———	*i-wi′-bru	du′-kwa	
snake	kĕ-bi′	———	b-gur′	———	ta-bek′
to sneeze	tser′-gĕ	———	shor-ke′		
soft	do-ru′-na	———			
sole of foot	kru+ptu′	———	shkon′-kwo	ku-kwo′-woi-ro	kras-kwa+plaŋ͡g
solid			kong′-e		
son	jĕ-ba′	———	wa	———	
sour	shkun′-a	———	shpo-et′-o	shpo-yon′-soi	
spider	si-a′-mu-nya	———	ting		
to spit	kar-i′	———	trung+woz′+ung	trung+twoz′-ung	

* Probably special names of *Helix Bulimus*, *Melania*, &c., as in Bri-bri dialect, *kwa*, in Tiribi evidently means shell.

English.	Cabecar of Estrella River.	Cabecar of Coen River.	Tiribi.	Terraba.	Brun-ka.
spleen	ko-u′	tak	wong	———	num
to spread			kwob-toz′+ung		
spy	ju-jet′-kuk	———	prob′-a		
to stand	her-wu′	———	jon′-ke	zhong-zhong′-ke	
star	koñg+wu′	———	d-bar-bo′	d-be-ra′-kwo	um′-ra
to steal	hog′-bru	———	ru-kez′+ung	rur′-ke	a-jañg′-li
stick	kar	———	kor′+lo	———	krang
to sting	m-her′	ka′-wa	ta-wa′-ru	shor-ke′-zo	
to stink	sa-ru-i+ha-rar′	su-ru-i+hrar′-ge	o-no′-et-o	o-no-oi′	
stone	hak	———	ak	———	kang
stool	krŭ-wa′	———	kruk	kru	
stop	ĕ-re′-re	he-re-re′	ko-shoz′+ŭ	———	
straight	mog-i′	———	i′-teng	kro-bek′-oi	du-u′-ka
to strike	it-pu′	———	i-ruz′+ong	sphoz′-ung	
strong	d-re′-re	———	d-bo-e′-to	kang′-ku-i	s-du-ru-re′
sugar	pash-tu′+chi-ka	———	jir′-bo-sho	sror′-bo-sho	
sun	di	di′-wo	do-ro′	———	kak
sure			zog′-u-de		
to swallow			d-kwoz′+ung	d-woz′-ung	
to sweat	pa-re′-na	———	sho′-ri-a	sho-ri′-na	
sweet	bro′-na	bro	pre′-bre	———	
to swim	bo-wo-ku′	bo-kwu′	ah-weh′	we	a-bu′-ŭ-li
tail	i-m-nek′	———	proc	frac	kwan-tsa′
to take	i-tsa′-mi	i-tsu′-mi	kroz′+ung	———	
to talk	bk-tu′	———	tnoz′+ung	———	
tall	b-tsi-br-wi	———	kok+shko′	———	

tame			un-e′-bi	———	
tapir	na′-i	———	so	———	na-i′
to taste	tsoñg-sir′	———	kuz′+ong		
teeth	ka	———	ko-wo′	———	kas′-a
" (molars)		ka+nyuk	ap	———	kam′i
to tell	i-shu′	———	ir-o-tos′		
then	he-re′-re	he′-re-re	en′-i	er′-a-ga	
there	wa-ji′-ga	di-ya′	kem′-nĕ	kim′-rish-ko	
they	he′-wa	ye	kweb′-ga	eb′-ga	i-rošhk
thick	kro-na-bi-ti′	hu-re′			
thief	hak	hak-bru′-gi			
thigh	tu-bru	———	kwor′-wo		
to think	her-wik′	———	wo-tniz′+ung	woi′-du	
thirst	her-ba′-na	her-si′	baum′-gung		
thorn					kwa
thou	ba	———	pa	fa	ba+a-bi′
throat				beng′-so	
to throw	i-hu-wa-mi′	i-tu′	d-buz′+ung	———	
thumb	u-ra+sku+in′-ga	———	sak-wo+kes′-yu	sak-wo+kes′-i	
thunder	hŭ-ra′	a′-ra	krik	———	kak′+an-te-gra
tick	ban′-o-wa	kas′-o-wa	tri′-gua		
to tickle	gi-pa′	———	yi-gru-woz′+ung		
to tie	i-mo′-a	———	kro-di-oz′-ung	kro-tenz′-ung	
tiger (spotted)	na-ma+kro′-na	———	d-kro+tong	d-boñg+tan-tan′-e	ku-ra′
" (black)	na-ma+do-ro′-na	———	kro+zi′-a	d-boñg+kro-si′-a	
" (red)	na-ma+mat′-ka	———	kro+sri-zrin′	shu-ring+d-boñg′	
time (future)	ma-nya-ni′	nya-nya+si-nye′-ta	pĕs-ir′-e	de-nash′-ko	

English.	Cabecar of Estrella River.	Cabecar of Coen River.	Tiribi.	Terraba.	Brun-ka.
time (past)	ba-ha′-si	nya-nya′	den-ai′	po-nyash′-ko	
tired	hĕ-rĕ-be′-na	———	sen-oi′	———	j-ro′-sha-ra
toad			krok	kro′-we	kshuk
tobacco	dŭ-wa′	———	do-wo′	———	du-a′
to-day	hir	———	er′-i	———	cha
toes	kras′-ku	———	sap′-kwo	———	
together	mya′-ra	———	hu′-nĕ	sha-ra′	
to-morrow	bu-ri′-ri	———	i-bong′	i-bon′-a-ga	sek
tongue	kok′-tu	kuk′-tu	kior′-kwo	ker′-kwo	kwat′-kwa
top of head	tsŭ-kuŋ̍g′+bĕ-ta	tsong′+bĕ-ta	kwa-dru-i-bo′		
tortoise	kwi	———	kwe	bog-o′	ba-eg′-ri
to touch	bŭ-rat-ku′	———	por-woz′+ung		
tree	kar	———	kor	———	krang
tribe	wag′+ĕ-ru	———	io-no′	———	
trunk of tree	kar	———	kor+i′-do		
to try	he-man′-i	———	tŭ-uit′		
to turn	men-e′-wa	———	wor-kwo′+zu		
twice					bug-ŭ-dek′
to twist			doz′+ung	zhu-iz′-ung	
ugly			so-o′-wa	———	
ulcer	shum-e′	———	zbing		
uncle	no-wa	naung	ke′-ga		
under	d-king′-ga	———	i-dor′-ko	tush′-ko	a-de′-bi
to understand	je-na-he′-ra	te-sa′	ku′-rob-dĕ	ko-kuz′-ong	
unripe			kro-pro-pru′-gi		
until			pe-si′-re		

valley	koñg+d-choi′	———	ztomb	zdam	
vein	ham-e′	———			
vine	ksa	———	kij′-wo	———	san-kwa′
voice	har′-ke	———	krun		
to vomit	i-tu′-wa	———	yar-we′	ya′-twe	
waist	ki-pa′	———			
to wait	kin-su′	———	ko-shoz′-ung	———	
to walk	i-shku′	———	hik	ik	
to want	ki-a-na′	———	woi-det′	———	
wasp	bu-kra′	———	wŏ-ro′	wo-rok′	srung-wa′
water	di-kru′	———	di	———	di
wax	har	bur′+i-nya	sot	on′-cham	but
we	sĕ-ha′	———		shing	ja-a-bi′
well	boe′	———			
wet	kis′-u	nun-a′-ga	puk-tong′-ĕ	pu-hu′-i	se-kar′
what	hi-ru′-in	er-hi′-i	kon-e-kro′-ti	zhe	
when	mi′-ga	———	jon′-wro	zhon′-wa	i′-ik
where					je
which	men-ĕ′	———	kon-e-de′		
to whisper	ka-kwa′	jĭ-kwa′	ba-tnez-wor′-a	kob′-wo+ba-kwoz-ung	kos′-wa
to whistle	ka-kun′-e	ka-kun′	b-ko′-ba-kwe		tsišh-kung
white	su-ru′-ru	———	plu-blun′	kru-ru′-ni	su-wat′
who	ji	———	i	e	di′-a
whole	har-e′-bu	kra-be′	kwo-hik′	i-don′-hi	
why					io′-ge
wide	shon′-a	shon	ba-met′-o	star′-e	wan-ka-li′
wife	(je+)ĕ-ra′-kra-wa	(je+)ĕ-ra′-kra	(bor+)iok′	(bor+)wa-re′	i-ra-rok′

English.	Cabecar of Estrella River.	Cabecar of Coen River.	Tiribi.	Terraba.	Brun-ka.
wild	kar+ŭ-bu′	———	kro-hi′		
wind	si-wang	———	pruc	———	shung
woman	ĕ-ra′-kra-wa	ĕ-ra -kra	wa-re′	———	i-ra-matk′
worn	d-cho′-nya	———	chus′-kro	———	
worse	se-ru-i+si′	———			
to wring		diu′-tru	zhguiz′+ung		
wrist	wu′-gĕ-cha	———	ork-wo+dok′		
yellow	psi	———	shoin′-lot	shoi-ran͡g′-i	sho-o-sat′
yes	hŭ′-ŭ	———	ing	———	u′-ge
yesterday	jĕ-ki	———	kub′-kĕ	kub-kesh′-ko	bi-ik
you	bas	be	ta-wa	fai-rung′-kwe	bi-roshk
your			poi	to-nya′	

THE EFFECT OF MAGNETIC AND GALVANIC FORCES UPON THE STRENGTH OF, AND DESTRUCTION OF IRON AND STEEL STRUCTURES.

By Charles M. Cresson, M.D.

(*Read before the American Philosophical Society, June* 18, 1875.)

Bars and Structures of Iron and Steel when allowed to remain at rest for a considerable time acquire measurable magnetic polarity.

Moderate percussion, alternations of heat and cold, exposure to the rays of the sun, especially with a long axis of figure parallel, or nearly coincident with a magnetic meridian of the earth, have a tendency to develop and strengthen magnetic polarity.

Thus, Iron Bridges, Iron Vessels upon the stocks in progress of construction, and Iron Railway Tracks are particularly liable to acquire magnetic polarity.

It is asserted that the relative position of the long axis of Iron Ships with reference to the magnetic meridian materially affects their polarity and the facility of the correction of their compasses.

If the keels of such vessels be laid on a North and South line, they are supposed to acquire greater polarity, and to retain it more steadily than when laid East and West.

The evidence of an iron ship's polarity is exhibited to the greatest degree, by comparison of its effects upon its compasses when the vessel is sailing in an easterly or westerly direction.

A consideration of the following facts seems to favor the conclusion that magnetic bars of Iron should be better able to resist tensile strain than those which are not magnetic.

A thoroughly magnetic bar is one of which each end repels a pole of a magnetic needle. The centre of such a bar is neutral, that is attracts either end of a magnetic needle and repels neither.

If we break such a bar in half, we are possessed of two magnetic bars; that end of the original bar which attracted the south end of a magnetic needle continues to attract it, that which attracted the north end continues to do so, whilst the two new ends which had formed the neutral centre of the original bar, each acquires a polarity opposite to the other, and also opposite to that possessed by its own opposite end. A continuance of this process, that is, the fracturing of each half until we have obtained such minute fragments of the bar as can be examined only under the microscope, still produces perfectly polarized bars, possessing all of the magnetic characteristics of the original bar, with varying, attracting, and repelling force according to some ratio of the relative length and thickness of the fragments.

Arguing upon this, we are led to the conclusion that a continuance of this process must produce molecular magnets.

If we place magnetic bars in contact with each other, the north and south poles alternating and in contact with each other, we obtain a metallic

chain of considerable strength, although its component parts are not mechanically connected together. The closer the contact of the ends of the bars the stronger will be the chain.

If with isolated bars we can obtain a connecting force equal to many pounds by close contact, how much stronger must be the connecting force when exerted between molecule and molecule.

Such an argument undoubtedly leads to the conclusion that bars saturated with magnetic force should certainly be stronger than those that are not.

Faraday announced that "there existed lines of force within the magnet of the same *nature* as those without. What is more they are exactly equal in *amount* with those without. They have a relation in *direction* to those without; in fact are continuations of them, absolutely unchanged in their nature."

To determine the effect of magnetic force upon the tensile strength of Iron and Steel,* bars of each were selected and cut into suitable lengths for use in the breaking machine and numbered.

Nos. 1, 3, 5, &c., were broken in the usual manner.

Nos. 2, 4, 6, &c., whilst in the breaking machine were surrounded by a suitable coil of copper-wire, through which a current of galvanic electricity was passed during the operation of breaking.

The results obtained from the magnetic Steel bars were about one per cent. less than those obtained from the non-magnetic, and from the magnetic soft Iron bars about three per cent. less than from the non-magnetic.

Both the Steel and Iron bars became heated whilst within the influence of the current of electricity, the soft Iron more so than the Steel.

It occurred to me that the depreciation of strength might have been caused by the rise of temperature† in the bars, and I accordingly prepared permanent magnets from alternate sections of a steel bar and repeated the experiments comparing the cold magnets with the unmagnetized sections of the same bar. The results showed no appreciable difference in strength between the magnetic and non-magnetic sections.

To test the matter still further, bars of Steel were so magnetized as to present a pole at one end, the other in the middle of the bar, with one end neutral, that is, one end of the bar attracted the North or South pole of a magnetic needle and repelled the South or North, and the other end of the bar attracted either pole of a magnetic needle.

* The Steel employed in the experiment was "Jessop's Round Machinery," ½ inch rod—

and broke at { maximum, 127.934 lbs.
minimum, 125,694 lbs.
per square inch of section.

The Iron broke at { maximum, 59,948 lbs.
minimum, 56,887 lbs.
per square inch of section.

† For effects of temperature upon the tensile strength of Iron, see Report of the Committee of the Franklin Institute of Pennsylvania,—"upon the strength of materials employed in the construction of Steam Boilers." Experiments made at the request of the Treasury Department of the United States (Jan'y 4th, 1831—Jan'y 5th, 1837).

Under these conditions if there was any effect to be had from the influence of the magnetic force, the bar should incline to break either at the central pole or at the neutral point between the poles.

The results of the experiments showed that there was no inclination to a choice of either location as the place of fracture.

The conclusion arrived at, is, that *the condition of magnetic polarity does not in any way influence the strength of steel bars.* With reference to the soft iron bars the comparison was not made, for the reason that they would not remain magnetic unless surrounded by the galvanic coil, in which case they became heated by the action of the current.

How far a change from fibrous to crystalline structure is effected by the influence of magnetism has not been ascertained, or whether there is any deterioration of the strength of iron or steel on such account.

Iron telegraph wires, in the course of time become brittle, and to such an extent that if the usual method of uniting them by winding each upon the other is attempted, they are frequently broken in the process.

From this it would appear that the passage of a strong galvanic current produces some molecular change affecting the strength of iron. Such conducting wires, however, are not necessarily or even usually magnetic. There can be no doubt, however, as to the deteriorating effect of *galvanic* force as an accelerator of oxidation or the solution of a metal.

Observations upon Iron Bridges and structures subjected to atmospheric influences and upon Boilers exposed to the action of heat and the chemical agents contained in ordinary waters lead to the conclusion that galvanic force is usually as great, and frequently a far greater cause of deterioration than mechanical wear. Indeeed all of the operations of nature, organic and inorganic, both constructive and disjunctive, involve the production of more or less galvanic force or are the results of its action.

Motion, unaccompanied by any other apparent change than that of place, is a disturber of electric or galvanic equilibrium, and the converse is equally true. If it were possible to produce perfectly pure and homogeneous iron, then the generation of destructive galvanic currents by the contact of sheets or bars would not take place.

By exercising care in the selection of iron, especially that used for steam boilers, the deterioration from galvanic action can be reduced to a minimum.

Many steam boilers have come under my observation in which the corrosion was but slight, and affected all parts equally, others in which the metal of a single sheet only was attacked, the corrosion of which sheet protected the remainder of the boiler almost as efficiently as if the sheet had been replaced by one of the metal zinc.

The most striking instance of the effect of introducing a sheet of metal of greatly differing electro-condition, that occurs to me, is that of a boiler which had been in use for a considerable length of time without showing any unusual tendency to corrosion, when from some cause it became necessary to replace a sheet by a new one.

The result of the introduction of a new sheet was to set up at once a strong galvanic action by which every sheet in the boiler was corroded except the new one.

Samples of iron cut from the edges of the old and from the new sheets were placed in a bath to which a few drops of dilute acid were added and a connection made with a galvanometer, resulting in the production of a strong current; the purer iron corroding, and protecting that which contained the greatest amount of carbon.

The inciting cause of the galvanic action was therefore judged to be the introduction of a sheet of iron electro-negative to those already in the boiler, its position in the electro-chemical scale depending upon the amount of carbon it contained.

The injurious effect consequent upon the junction of masses of wrought iron of varying electro-chemical properties, is, therefore, increased when *steel* is joined to wrought iron, as is frequently the case in locomotive boilers in the tubes and tube sheets.

Again by the junction of *cast iron* to steel or to wrought iron, the destructive effect is greatly intensified, and at times becomes quite as violent as when copper is made an element in the galvanic circuit in connection with wrought iron.

The necessity for the selection of iron with reference to its electric condition, applies equally to the material employed for Bridges or Vessels or Boilers or any structure which is to be built up from separate sheets and bars of iron.

It is or ought to be the habit of careful constructors to cut sample pieces from every sheet or bar of metal worked, and to make a trial of their quality by bending hot and cold, and to make frequent tests of tensile strength. Examinations as to electro-chemical condition can be made with equal facility. Determinations of the composition of the metal or of the percentage of carbon in it by chemical analysis are unnecessary; an ordinary workman furnished with a coarse galvanometer and a weak acid bath can ascertain the exact electro-condition of each sheet or bar more rapidly than he can examine the quality by the ordinary tests of bending on an anvil, hot and cold. With the metal of Bridges, Vessels, and especially Steam Boilers, the deterioration by corrosion is more to be feared than is mechanical wear.

Galvanic corrosion acts with greater vigor in locations that are usually inaccessible, such as the interior of joints or defective sheets or parts that are closely approximated, and the mischief is only suspected when it has progressed to such a degree as to become evidently dangerous and the parts are in condition to require immediate attention and repair.

Attention to the precautions enumerated for securing mechanical and chemical fitness of the metal to be used for structures of iron, will undoubtedly promote economy and safety.

FURTHER RELATIONS OF MAGNETIC, GRAVITATING, AND LUMINOUS FORCE.

By Pliny Earle Chase,

Professor of Mathematics in Haverford College.

(*Read before the American Philosophical Society, June* 18, 1875.)

Ohm's law is a particular case of the general principle that an impulsive force may be measured by the product of resistance overcome, by velocity communicated. Illustrations of this principle may be found

In General Physics,	Mass	× Velocity	= Momentum;
In Electricity,	Resistance	× Current	= Electromotive force;
In Chemistry,	Atomic weight	× Specific heat	= Chemical constant;
In Cosmogony,	Inertia-resistance	× Gravitating impulse	= Centripetal constant

Since all these expressions refer to actions from or towards given centres, they are governed by the same mathematical relations, and the different names by which the activities are designated, do not necessarily imply any differences in the nature of the forces themselves.

Clerk Maxwell asks,* "Is it possible that the attraction of [the Sun and Moon], by causing strains in the interior of the earth, produces changes in the magnetism of the Earth, and so by a kind of tidal action causes the semidiurnal variations?" Eleven years ago, in the paper which received the Magellanic gold medal, and in other communications,† I anticipated the question, and gave reasons for answering it in the affirmative.

If the primary disturbance is of a tidal character, it does not involve the entire force of $[M]$, but merely the differential force $[ML^{-3}]$. If we regard the electric $[M^{\frac{1}{2}}]$ as really representing $[M^{\frac{1}{2}}L^{\frac{4}{2}}]$, each of the mass-factors in Maxwell's table of electrostatic and electromagnetic dimensions should be multiplied by $[L^{-\frac{8}{2}}]$. This multiplication produces a *precise correspondence* between the electrical and gravitating fields, both in extent, and in many suggestive details.

In my communication on the "Velocity of Primitive Undulations,"‡ I showed that the present numerical value of the velocity-ratio, lt^{-1}, at its upper limit, or the limit between total solar dissociation and incipient aggregation, is the velocity of light, and that the planetary ratios are also in close accordance with the ratio between the radius of gyration of the solar system when nebulously diffused, and Sun's radius of gyration about the centre of gravity of the system. If we wish to extend our comparisons to the lower limit, or the limit between total aggregation and commencing dissociation, the directions of $v_{/}$ and $r_{//}$ should be taken tangentially instead of radially. Designating the symbols for the lower limit by enclosures we have $(v_{/}) = v_{/} \div \sqrt{2}$; $(v_{//}) = \frac{\pi}{2} v_{//}$; $(lt^{-1}) = (v_{/} \div v_{//}) = \frac{\sqrt{2}}{\pi} lt^{-1}$; $(v_0) = (v_{/}) \times (lt^{-1}) = v_0 \div \pi$. Therefore *the maxi-*

* "Treatise on Electricity and Magnetism," ii, 127.

† Proc. Amer. Philos. Soc., ix, 356, 357, 427, 487, &c.

‡ Proc. Amer. Assoc. Adv. Sci., xxiii, 99.

mum velocity of possible cohesion in our system, is to the minimum velocity of complete dissociation (or the velocity of light), as the diameter of a circle is to its circumference. This relationship points to a kind of circular polarization, induced by the resistance of centres of inertia, as the mediate cause of aggregation by the primitive undulations.

In the following table the principal harmonies which I have pointed out are synoptically shown. It should be remembered that $(v) = (lt^{-1}) \propto l^{-\frac{1}{2}} \propto t^{-\frac{1}{3}}$; $n = \sqrt{2} \div \pi$; the variants in the right-hand column are symbols of electric dimensions. I have adopted Maxwell's notation with the addition of an accent to mark the symbols of the electro-magnetic system:

$$\begin{array}{lll}
\mathrm{M} & = \pi n^{-4} (\mathrm{M}) & \propto (v)^4 \propto \mathfrak{C} \\
a & = \pi n^{-3} (a) & \propto (v)^3 \propto \mathfrak{C}' \\
2r & = \pi n^{-2} (2r) & \propto (v)^2 \propto \mathfrak{E}', \mathfrak{A} \\
\beta & = \pi n^{-1} (\beta) & \propto (v)^1 \propto \mathfrak{E}, \mathfrak{A}', \mathfrak{B}', \mathrm{R}', \mathfrak{D} \\
v_0 & = \pi n^0 (v_0) & \propto (v)^0 \propto \mathrm{E}', \mathrm{C}, \mathfrak{B}, \mathrm{K}, \mathfrak{D}', \mu', \Omega \\
v_{/} & = \pi n^1 (v_{/}) & \propto (v)^{-1} \propto \mathrm{E}, \mathrm{C}', \mathfrak{A}', \mathrm{R}, r' \quad \Omega' \\
v_{//} & = \pi n^2 (v_{//}) & \propto (v)^{-2} \propto \mathrm{L}', \mathfrak{A}, \mathrm{K}', q, \mu \\
\gamma & = \pi n^3 (\gamma) & \propto (v)^{-3} \propto m', e, p', r \\
v_{///} & = \pi n^4 (v_{///}) & \propto (v)^{-4} \propto m, \mathrm{L}, e', p, q'
\end{array}$$

In this table, M = the primary modulus = twice the virtual fall, or the height of a homogeneous æthereal atmosphere at Sun's surface, which would progagate undulations with the velocity of light, the time of virtual fall being half a solar rotation.

$2r$ = Sun's diameter.

v_0 = velocity of light.

$v_{/}$ = maximum velocity communicable by solar attraction $= \sqrt{2gr}$ at Sun's surface.

$(v_{/})$ = maximum velocity of orbital revolution in our system $= \sqrt{gr}$ at Sun's surface.

$v_{//}$ = mean equatorial velocity of radial oscillation with reference to the Central Sun, producing solar rotation.

$(v_{//})$ = equatorial velocity of solar rotation.

$v_{///}$ = falling velocity communicated, at Sun's equatorial surface, by virtual fall through the half-radius of a circumference equivalent to a red wave-length.

If all the internal resistances of the Sun were converted into motion, the values of (v) and of all its powers would become unity, and *all of the above tabular values would become equivalent to the velocity of light.*

In one of my early papers on the correlations of gravity and magnetism,* while seeking experimental evidence of their mutual interdependence, I called attention to the fact that only about $\frac{1}{250}$ of the potential energy of gravity can be converted into actual energy, the re-

* Proc. A. P. S., ix, 356–7.

mainder being opposed by the reaction of molecular elasticity. Maxwell* has suggested a crucial experiment of a similar character to the one I then sought. The velocity of his electrified disc bears nearly the same ratio to Earth's orbital velocity, as the diminution of terrestrial attraction by equatorial centrifugal force (or actual energy of superficial gravity) bears to the total attraction. The magnetic disturbance of the disc : Earth's horizontal magnetic force : : the molecular *vis viva* † of equatorial rotation : the molecular *vis viva* of orbital revolution.

The molecular oscillation, in alternate approach to and recess from the orbital centre, continues for a half-rotation or a half-revolution, while the terrestrial antagonism lasts only $\frac{1}{\pi}$ as long. If we distinguish the terrestrial from the solar units by subscript accents, $l_{\prime} = l$; $t_{\prime} = \frac{t}{\pi}$; and, if magnetism and gravitation are tidally related, Maxwell's data‡ may be represented by the following proportionate tensions :

$m_{\prime}^2\, l_{\prime}^2\, t_{\prime}^{-4} : m^2 l^2 t^{-4} : : m_{\prime}^2 \pi^4 : m^2 : : .128 : 140 \times 144 \times 7000 \therefore : 1 :$ 1102500000. Then $m_{\prime}^2 : m^2 : : 1 : 1102500000\pi^4$, and $m = 327710\, m_{\prime}$. This gives a solar parallax of $\sqrt[3]{\frac{10^9}{4.432m}} = 8''.83$, which is $\frac{1}{3}$ of one per cent. less than Cornu's parallax.

PLANETARY ILLUSTRATIONS OF THE CREATIVE FIAT.

By Pliny Earle Chase.

(*Read before the American Philosophical Society, Aug.* 20, 1875.)

In various communications to the American Philosophical Society and to the American Association, I have shown that—

1. The same principles of inertia which cause the Foucault pendulum to record the Earth's rotation, also register the Sun's influence, in sound waves, barometric waves, magnetic variations, mean temperatures, nascent velocities both chemical and cosmical, solar and planetary masses and moments, and stellar and planetary harmonies of relative position, rotation, and revolution.

2. Various independent inertia-estimates of solar distance may be thus obtained, differing from Cornu's final estimate in amounts varying between $\frac{3}{40}$ of one per cent. and $\frac{7}{10}$ of one per cent.

3. All the physical activities which I have tested, seem explicable by ætherial waves, propagated with the velocity of light.

4. Between *a Centauri* and the Sun a parabola can be traced, governed by the solar modulus of light, and determining planetary positions.

* Op. Cit., ii, 370.

† The influence of molecular *vis viva* was shown in my discussion of barometric tides, (*ante*, ix, 287). Imray also recognizes its importance in elevating the centre of the molecule, in wave movement, above the normal level, (Proc. Roy. Soc., No. 153. pp. 352–3).

‡ Ib., ii, 258.

5. In studying the phenomena of exploding hydrogen and oxygen, in order to determine the comparative reaction of Earth and Sun upon the disturbed inertia, and their consequent relative masses, it is necessary to consider the "centres of explosive oscillation," at $\frac{4}{9}$ and $\frac{5}{9}$ of the total excursion of particles from either extremity.

6. In all perpetual movements of mutual alternate approach and regress, there is a double tendency towards centres of gravity and centres of linear oscillation, due to the action of centripetal and centrifugal equilibrating forces, analogous to the tendency in simple explosion.

7. Consequently the ratios $\frac{4}{9}$ and $\frac{5}{9}$, $[(\frac{2}{3})^2$ and $1-(\frac{2}{3})^2]$, are found largely prevalent in planeto-taxis.

8. Rotation and orbital revolution are due to the operation of the same forces, rotation being merely revolution retarded by internal pressure.

9. The velocity of rotation varying inversely as radius, while the velocity of revolution varies inversely as the square-root of radius, the two velocities, in a cooling and shrinking mass, tend to approximate equality. If matter were infinitely divisible, or if the theory of Boscovich were true, they would finally become equal, and, if shrinkage still continued, the preponderating centrifugal force of rotation would lead to disintegration.

10. Whatever may be the ultimate constitution of matter, the internal resistances of heat-volume, mass-inertia, and other interferences of known and unknown forms, must be the same in the aggregate as if the theory of Boscovich were true. Therefore, by finding the limits of equality in accordance with that theory, we may find the limiting velocities of the primitive force.

11. Those limits may be studied tangentially, by comparing the equatorial velocity of rotation with the velocity of circular revolution at the same point $\left(\sqrt{gr}\right)$; radially, by comparing the velocity acquired through fall from an infinite distance, $\left(\sqrt{2gr}\right)$, with the mean velocity of radial oscillation due to rotation and synchronous with it $\left(\frac{2}{\pi}\right.$ of the velocity of rotation$\left.\right)$. At the points of equality, the former limit marks the boundary between complete aggregation and commencing dissociation; the latter, between complete dissociation and commencing aggregation.

12. Calculating these limits for the principal bodies of the solar system, we find that complete dissociation would take place in all the subordinate planets before their rotation-speed had increased to the limiting velocity of aggregation in Earth and Jupiter; complete dissociation would take place in Earth and Jupiter, when their rotation-speed had attained the present limit of possible circular revolution, at the centre of gravity of Sun and Jupiter; the limit of solar aggregation is $\frac{1}{\pi}$ of the velocity of light; the potential of solar attractive force would give the velocity of light; the limit of solar dissociation is the velocity of light; the limit of planetary dissociation would carry a particle around the Sun while a ray of light was passing from the orbit of Uranus, through Sun,

to Earth's orbit, a distance equivalent to $\frac{2}{3}$ Neptune's mean radius vector, or to the true length of the linear pendulum of Sun's outermost planet; the time-ratio of Earth's rotation to Jupiter's revolution, is the same as the ratio of Sun's radius to the primary pendulum.

Combining these several results with the accordances of electrical velocity and chemical affinity, which have been discovered by Weber and Kohlrausch, Thomson, Clerk Maxwell, and Edlund, and with the explosive energy of hydrogen, which brings all chemical attraction into simple correlation with gravitating attraction, we find a profound scientific truth in the doctrine that the first act of creation was the Divine command, LET THERE BE LIGHT.

La Place's calculation that gravitating action involved a velocity at least six million times as great as that of light, may, perhaps, as President Lovering well suggested in his Hartford address, require revision in order to make allowance for additional data. In a substance, either of infinite elasticity, or of no density, (and, therefore, spiritual?) undulations would be propagated with infinite velocity. It is easily conceivable, either that the transverse vibrations of luminous waves, which have been studied, are accompanied by co-ordinate undulations of much greater speed, which have hitherto escaped notice, or that there is some other kind of motion to be considered than that of simple undulation. In a medium for the transmission of force, endowed with immense elasticity and with such slight mobility of particles as Fresnel supposed, may there not be a quasi rigidity in "lines of force" when compared with such low stresses as those of tidal influence, which will account both for the rapidity of gravitating action, and for the more than steel-like firmness which Sir Wm. Thomson attributes to the Earth's mass? The greatest possible manifestation of gravitating velocity in the solar system, $\sqrt{2\,gr}$, is equivalent to that communicated by virtual fall, at Sun's surface, in 2255 seconds. Since this velocity is only $\frac{1}{486.7}$ as great as the velocity of light, and since there are 103 $(10)^{16}$ waves in 2255 seconds, only $\frac{1}{501\,(10)^{18}}$ of the velocity of its own transmission need be imparted by each wave for producing the ultimate aggregate of gravitating motion.

Looking still further into the internal constitution of the solar system, we find that the angular velocity of revolution at twice Neptune's distance, equals the angular velocity of rotation due to a solar radius extending to Mercury's mean distance, a coincidence suggesting probable asteroidal or planetary masses beyond Neptune in a way similar to my harmonic indication of matter within Mercury's orbit, revolving in a time, which was subsequently confirmed by the Sun-spot observations of De La Rue, Stewart, and Loewy. Inasmuch as the velocity communicated by infinite fall to any radius vector, equals the velocity of circular revolution at half that radius, this accordance seems to have fixed the limits of the planetary belts. Within those limits, planetary positions may be referred to simple circular pendulums, which are so related that their harmonic vi-

brations tend to maintain the stability of the system. The pendulum unit is $\frac{9}{4}$ Sun's radius, Sun's surface being at a centre of explosive oscillation.

The time of rotation for a given radius varying as the $\frac{4}{3}$ power of the time of revolution for the same radius, the theoretical distance of each planet may be found by multiplying the $\frac{4}{3}$ power of its number of pendulum units by the value of the unit. Symbolizing each pendulum by its planet's initial letters, the following table gives a comparison of theoretical and actual mean distances. The second column *exactly* represents planetary positions, although, on account of orbital eccentricities and mutual perturbations, it only represents *mean* positions with a very close approximation.

	No. of Pend. Units.	(A) Theoretical Mean Distance.	(B) Actual Mean Distance.	(A–B) ÷ (B)
Me.	15	83.23	83.17	+ .0007
Ve.	24	155.76	155.42	+ .0022
Ea.	30	209.74	214.86	— .0239
Ma.	42	328.48	327.38	+ .0034
Ju.	105	1114.75	1117.87	— .0028
Sa.	168	2085.75	2049.51	+ .0177
Ur.	280	4121.54	4121.78	— .0001
Ne.	392	6455.03	6453.06	+ .0003

The pendulum orbits may be referred to extremities, or to centres of oscillation of linear pendulums, as follows:

	Ex.	*c. o.*	*c. o.*	*Ex.*
1.	Ne.	Ur.	Sa.	Sa. c. o. (= $\frac{1}{3}$ Sa.)
2.	Sa.	Ju.	Ma.	⊙ Ma. c.g. (= $\frac{1}{2}$ Ma.)
3.	Ma.		Ea.	Ve.
4.	Ma.		Ve.	Me.
5.	Ea.	Me.	⊙	Me.
6.	Ve.	$\frac{1}{2}$ Ma.		Me.

Each of the divisions of the first pendulum is equivalent to the diameter of a Sun extending to the centre of oscillation of Sa., and the pendulum orbit is symmetrically divided on both sides of the Sun.

Each of the divisions of the second pendulum is equivalent to a pendulum, of which Sun occupies a centre of oscillation, and Mars a centre of vibration.

If all physical force is transmitted through the medium of an elastic æther, the foregoing accordances seem to illustrate the well-known law, that where points of gross inertia are established in an elastic medium, and exposed to undulations from every direction, as the distances increase in arithmetical progression the densities decrease in harmonic progression.

YEARLY RAINFALL IN THE UNITED STATES.

By Pliny Earle Chase,

Professor of Mathematics in Haverford College.

(*Read before the American Philosophical Society, August* 20, 1875.)

At the Society's Meeting, on the 16th of April last, I submitted a communication on the Lunar-Monthly rainfall in the United States, as deduced from an examination of the morning weather maps issued by the Signal Service Bureau. The maps extended over a period of about three years, and as the average number of reporting stations was about sixty, the results represented an average of at least 2000 observations for each of the thirty lunar-monthly days. For various reasons, enumerated in the communication, the derived normals should be regarded as only provisional; still, the regularity of the curve, its magnitude, its resemblance to the Philadelphia curve for 43 years, and the indications of disturbances originating beyond the Mississippi river, seem to justify my estimate of the importance of such general comparisons as our National Bureau has for the first time made possible.

In order to provide still further material for future use, I have tabulated the same observations with reference to Earth's annual course around the Sun. The rainfall for each year is divided into 30 periods of 12 or 13 days each, always dividing to the nearest day, the first division embracing the last six days of one year, and the first six days of the following year. The total fall for each period was divided by the total number of reports for the same period, and the normals were deduced from the resulting averages in the same manner as in my previous meteorological papers. These normals, as given in the accompanying table, indicate an average solar disturbance about 2.3 times as great as the lunar. This suggests some kind of *reciprocal* tidal action, and it seems also to point towards an important cosmical law, but more extended observations and comparisons are needful in order to justify any conclusive decision. There are some resemblances between the present curve and the corresponding lunar-monthly curve which seem worthy of study, but it is perhaps better to postpone their critical examination, until their significance is either confirmed or changed by the observations for one or more additional periods of like duration. For the convenience of those who may desire to make comparisons without waiting for further data, I copy the lunar normals alongside of the solar.

opinion as to whether the acid named is the one possessing the normal molecular structure given above, or is only an isomer of it, having its carbon atoms differently united. Notably with glyceric acid is this yet an open question. Some results lately obtained in the course of a study of this acid appear to me to be of value for the solution of this question.

The other view of the molecular structure of glyceric acid makes it unsymmetrical, two of the carbon atoms being doubly united. The formula given is

$$\begin{array}{l} \quad\;\; CH_2.OH. \\ \quad\;\; | \\ \;\;/C.OH \\ O\;\; | \\ \;\;\backslash CH.OH. \end{array}$$

As will be seen, this formula does not contain the Carboxyl group hitherto supposed to be the invariable characteristic of an organic acid. The author of this theory is Prof. Wislicenus, of Würzburg, and the following are the reasons given in support of it. If lactic acid be acted upon with hydrogen iodide, α iodo-propionic acid is formed, according to the following reaction:

$$\begin{array}{l} CH_3 \\ | \\ CH.OH \\ | \\ CO.OH \end{array} + HI = \begin{array}{l} CH_3 \\ | \\ CH.I \\ | \\ CO.OH. \end{array} + H.OH$$

This when heated to 150° with strong HI is changed into propionic acid. If, on the other hand, glyceric acid be acted upon with hydrogen iodide, β iodo-propionic acid is formed. If this had the formula

$$\begin{array}{l} CH_2I \\ | \\ CH_2 \\ | \\ CO.OH, \end{array}$$

on treatment with moist silver oxide, it would pass into ethylene lactic acid. It does not, however, do this, but a new acid isomeric with ethylene lactic acid is formed—hydracrylic—

$$\begin{array}{l} \quad\;\; CH_2.OH \\ \quad\;\; | \\ \;\;/CH \\ O\;\; | \\ \;\;\backslash CH.OH. \end{array}$$

That the molecular structure of this acid is essentially different from that of ethylene lactic acid is proved by the oxydation products of the two. Ethylene lactic acid yields malonic acid, while hydracrylic does not yield a trace of this, breaking up into glycolic and oxalic acids and carbonic dioxide. Moreover, hydracrylic acid on heating yields acrylic acid, a derivative of allyl alcohol, instead of the lactid yielded by the lactic acids.

Prof Wislicenus, however, frankly gives one experiment made by himself, the result of which tends the other way. He reduced the β iodo-propionic acid by sodium amalgam and obtained what appeared to be the normal propionic acid, showing the regular molecular structure.

In favor moreover of the normal structure for the molecule of glyceric acid is the formation of pyruvic or pyroracemic acid

$$\begin{array}{l} CH_3 \\ | \\ CO \\ | \\ CO.OH \end{array}$$

from glyceric acid upon heating this to 140°, explained by the following reaction:

$$\begin{array}{l} CH_2.OH \\ | \\ CH.OH \\ | \\ CO.OH \end{array} - H.OH = \begin{array}{l} CH_3 \\ | \\ CO \\ | \\ CO.OH. \end{array}$$

The structure of this pyruvic acid is known from the fact that acted upon by nascent hydrogen it gives normal lactic acid.

A strong additional argument would be had, if we could show a connection between glyceric acid,

$$\begin{array}{l} CH_2.OH \\ | \\ CH.OH \\ | \\ CO.OH \end{array}$$

and tartronic acid,

$$\begin{array}{l} CO.OH \\ | \\ CH.OH \\ | \\ CO.OH. \end{array}$$

Hitherto tartronic acid had not been formed from glyceric acid, but only in an indirect way, by the spontaneous decomposition of nitro-tartaric acid, according to the following reaction:

$$\begin{array}{l} CO.OH \\ | \\ CH.O(NO_2) \\ | \\ CH.O(NO_2) \\ | \\ CO.OH \end{array} = \begin{array}{l} CO.OH \\ | \\ CH.OH \\ | \\ CO.OH \end{array} + N_2O_3 + CO_2$$

However this mode of formation was interesting as tending to show its symmetry of structure. For that matter a dibasic, triatomic acid could hardly exist, except by the assumption of two carboxyl groups.

I have been fortunate enough to find tartronic acid associated with glyceric acid in the oxydation products of glycerine. The preparation of the two acids was as follows: One part by weight of glycerine is mixed with one part of water, and to the mixture is added, by means of a long funnel tube reaching to the bottom of the cylinder, about one and a quarter parts of red fuming nitric acid. After allowing them to rest until all gas evolution has ceased, (which usually takes some six days,) the solution is evaporated down at a gentle heat until the fumes of nitric acid are no longer perceptible. It is then very thick and syrupy. It is now diluted with water, and plumbic carbonate is added in excess. The oxalate and undissolved carbonate are filtered off, and the solution slightly concentrated and allowed to crystallize. The glycerate of lead deposits in thick crystalline crusts. These are separated from the mother-liquor, dissolved, and the lead precipitated out from the solution by sulphuretted hydrogen.

The colorless or light straw-colored filtrate is somewhat concentrated, and calcic carbonate is added to neutralization. The solution is filtered, if necessary, and to the filtrate is added an equal volume of 95 per cent. alcohol. The calcium salts present are all precipitated, in greater part at once, and completely on standing twelve hours.

If the solution had been very concentrated the calcium salt is precipitated in a granular condition. If, on the other hand, it was more dilute, the salt only separates gradually, and has a beautiful micaceous and scaly appearance.

I had at first considered this precipitate to be pure calcium glycerate, but found on dissolving it in water, in order to free it from the lime and obtain the glyceric acid, that while the greater portion dissolved readily in warm water, a considerable portion, although not more than one-tenth of the whole amount, remained and dissolved only on continued boiling. This, when filtered off and washed in cold water, appeared as a dull white almost impalpable powder, contrasting in appearance with the crystalline glycerate.

It was dried carefully at 100° until constant weight was obtained.

Calcium determinations were first made. Weighted portions were ignited in a platinum crucible once or twice with excess of concentrated sulphuric acid until the weight remained constant.

.5755 grms. salt yielded .4925 grms. $CaSO_4$ equal to 25.22 per cent. Ca.

.1759 grms. salt yielded .1505 grms. $CaSO_4$ equal to 25.16 per cent. Ca.

The theoretical per cent. of calcium in calcium tartronate is 25 32, while in calcium glycerate, allowing for two molecules of water of crystallization, it is 13.99.

I had analyzed the micaceous preparation of calcium glycerate about the same time and had gotten in two determinations, 14.03, 14.07 per cent. of calcium respectively. The difference was so great that I could not understand it. On reckoning up the molecular weight, however, assuming one atom of calcium to be present, I got 159. The molecular weight of calcium tartronate is 158. Being dibasic, the molecular weight of the calcium compound is of course much less than the weight of the calcium compound of glyceric acid, a monobasic acid.

I endeavored twice to make a combustion of the salt in order to get the per cent. of hydrogen and carbon. Each time calcium carbonate remained undecomposed at the heat of the combustion. I therefore gave them up.

I then took the remainder of my salt, grown rather small, to my great regret, and neutralizing the lime with oxalic acid, obtained the free acid. This, on concentration, deposited out crystals. On examination with a lens they were seen to be of tabular form, well agreeing with the appearance of tartronic acid obtained from nitro-tartaric acid. A combustion was made of these, and here, unfortunately, an accident to the potash bulbs lost me the carbon determination. The hydrogen determination however, is given.

.4348 grms. salt yielded .1323 grms. H_2O equal to 3.38 per cent. hydrogen.

The theoretical per cent. of hydrogen in $C_3H_4O_5$ is 3.33.

An important test that I wished to make but was compelled to forego for the time, was to act upon this tartronic acid with hydrogen iodide. Were its structure symmetrical, it should yield α iodo-malonic acid, which by further treatment with HI or with reducing agents would yield malonic acid.

Wishing to obtain larger quantities of the tartronic acid for further examination, I have since oxydized another portion of glycerine and treated the products in the same way. This time I got no tartronic acid whatever, at least only a trace of calcium salt remained undissolved on heating with water. Evidently here the oxydation had proceeded somewhat differently as no tartronic acid formed. This result is not surprising on reflection, as the oxydation by nitric acid is not capable of much control, and a product once formed is liable to be still further oxydized. Thus glyceric and tartronic acids are both liable to be oxydized into oxalic acid, which always forms in considerable though varying quantity. Indeed the oxydation of glycerine by nitric acid is now known to yield a variety of products, of which, however, no doubt some are secondary ones.

Thus Heintz* has proved that racemic, formic, glycolic, and glyoxalic acids are all found associated with the glyceric and oxalic acids in this product.

The tartronic acid just found, therefore, is only one of several smaller side-products. The known symmetry of structure of the molecules of all these side products, however, certainly argues in favor of a similar symmetry in the glyceric acid molecule.

There is one way of reconciling these two views of the structure of glyceric acid, and that is the assumption of the existence of two isomeric acids, of which one is normal and the other an unsymmetrical acid.

Some results that I have just obtained in purifying the calcium glycerate seem, indeed, to point this way. Should the unsymmetrical glyceric acid preponderate in this mixture, Wislicenus' reactions with hydrogen iodide are readily understood. Another fact, which should not be lost sight of, is that in the decomposition of β iodo-propionic acid by moist silver oxide, Wislicenus† obtained not hydracrylic acid alone, but three other products accompaning it, so that the decomposition was not so simple.

I am now engaged upon a study of this question and hope to be able to give more information upon it, in a short time.

* Ann. der Ch. und Ph. 152, p. 325.

† Ann. der Ch. und Ph. 166, p. 41.

NOTES ON GLACIAL ACTION VISIBLE ALONG THE KITTATINNY OR BLUE MOUNTAIN, CARBON, NORTHAMPTON, AND MONROE COUNTIES, PENNSYLVANIA.

By Charles E. Hall.

(*Read before the American Philosophical Society, September* 17, 1875.)

My attention was first called to the fact of glaciers having existed along the Blue Mountain and south of it, from the vast deposits of boulders and pebbles south of the Lehigh Gap, and along the course of the Lehigh River. My observations have been limited, not having had time to devote to the subject.

South of the Lehigh Gap, about one-half mile below the chain bridge, on the east side of the river is a railroad cut through the slates of the Hudson River group, overlaid by a large bed of sands, gravel and boulders, having all the characteristics of a glacial deposit.

The slate has a dip to the southeastward, the upper edges of it are broken and crushed over to the southward, thus showing a force and weight moving in a southerly direction and obliging the slates to conform to it.

A similar exposure was observed three-fourths of a mile below Bowman's (second station above Lehigh Gap). Here in a railroad cut through the shale of VI, on the east side of the river, the rock is exposed for more than a hundred feet.

The rock dips S.20°E., the line of the exposure is S.40°E., and parallel to the exposure, or diagonally across the strike, are the edges of the shale overturned and broken, in some places to a depth of five or six feet. Here, too, the broken edges all incline to the southeastward, indicating the direction of the moving mass to be towards the Gap. The shale is very much crushed near the surface; above it is a heavy bed of fine sand, angular fragments of rock, and large boulders, most of them are from the Oriskany, some from the Chemung, but *none* from the Medina of the Blue Mountain.

Two hundred yards back of the Hotel at Bowman's, on the road to Fireline, the slates of the Hamilton present a similar appearance. The upper edges overturned and broken, and here show a movement to the southeastward.

We may conclude from these facts that the bed of the present river marks, to a great extent, the course of the glaciers.

To the east and west of the Gap, north of the mountain is a broad flat valley extending from the Oriskany Ridge to the base of the mountain. This valley is intersected by a barrier of debris extending from the Oriskany Ridge to a rounded hill of Clinton Shale and sandstone, a few hundred yards north of the Gap.

My attention was first called to this fact by Mr. H. Martyn Chance, who was then making a survey of the Gap.

The only explanation I can give of this, is, that it is a moraine formed

by the glacier after it had receded through the Gap, possibly a lateral moraine.

Wind Gap.

From the few evidences observed, I concluded that here, too, the glaciers had crossed the Blue Mountain Range. North of the Gap I observed nothing remarkable. South of the Gap are great numbers of boulders of Oneida conglomerate and Medina sandstone. They are strewn along for some distance in a direct line with the Gap, and apparently mark the course of a moving body.

Not having observed Oriskany sandstone associated with the boulders, I attributed to the fact of it being more easily disintegrated.

Delaware Water Gap.

The first notice I took of decided glacial action in this vicinity, was about four miles from the mouth of Marshall's Creek, on the road to Craig's Meadow, where there are extensive exposures of the Oriskany sandstone, undulating and pitching gently to the northward.

These beds, often quite level, are scored and scratched wherever exposed. Often several hundred square feet are laid bare by the road.

The direction of these grooves is S.28°W., showing the direction of the moving mass to be towards the Gap. That the motion was to southward can clearly be seen wherever there are slight rises in the rock, the northern side is more deeply grooved, and more polished than immediately south of it. The full weight of the mass being forced against the rise would not act with the same force till it had passed some distance beyond.

The same fact as remarked in the White Mountains by Agassiz, (?) where the northern slopes of the mountains are scored and grooved to their very summits, but the scratches do not appear till near the base on the Southern slopes.

There are evidences of a moraine about one mile north of the mouth of Marshall's Creek, near the mill-dam.

In the neighborhood of Craig's Meadows are large deposits of drift, probably glacial.

West and southwest of the Gap, about two miles, I observed polished and grooved surfaces of the Medina.

South of the Gap are large deposits of gravel and boulders, evidently glacial debris.

Between the Gap and Broadhead's Creek I observed some beautifully defined terraces, but was unable to trace them. These facts tend to prove that the Gaps existed before the glacial epoch, and that the present rivers mark, to some extent, the courses of the ice, at any rate, towards the close of that period.

THE BEGINNINGS OF DEVELOPMENT.

By Pliny Earle Chase,

Professor of Mathematics in Haverford College.

(*Read before the American Philosophical Society, September* 17, 1875.)

In speculations upon the nebular hypothesis exclusive regard has usually been paid to action at the limit of possible atmosphere, or the point at which the velocity of rotation becomes equal to the velocity of revolution. Hence many popular text books state that, if the Sun were expanded until it reached the orbit of each of the planets in succession, its times of rotation would correspond with their respective times of revolution. This statement is generally understood as referring to the expansion of the *nucleus*, and with such reference it is false.

The times of rotation vary as the squares of the nucleal radius, while the times of revolution vary as the $\frac{3}{2}$ power of the radius vector. The rotation-radius, or the radius of a nucleus which would have a rotation synchronous with orbital revolution, therefore varies as the $\frac{3}{4}$ power of the radius vector. In my communication on "Planetary Illustrations of the Creative Fiat," I represented the rotation radii by approximate circular pendulums, the pendulum-unit being $\frac{1}{8}$ of Sun's radius, because the centrifugal force, as Alexander has stated,* varies as $\frac{1}{d^3}$; and the distance at which the velocity acquired by infinite fall would equal orbital velocity at d, being 2 d, $\frac{1}{2^3} = \frac{1}{8}$. The unit of orbital distance is $\frac{3}{4}$ r, or $(\frac{1}{8})^{\frac{4}{3}}$ of the present height of possible solar atmosphere.

In the following table, the actual values of the rotation radii for the several planetary mean distances are given, for comparison with the theoretical pendulums and for further study. An inspection of the numbers of pendulum-units shows three simple nodal groupings, with a break between Earth and Mercury, and Venus serving as a link. If we extend the nodal divisions, we find that Earth appears to have established a secondary system of its own, drawing the larger portion of the nodal material from 18 to Venus, and uniting with Sun, Venus, and Venus-Mercury in carrying the rest to Mercury.

	Theoretical.	Actual.	Difference Ratio.
Prime Multiple	504		
	112		
Neptune,†	392	392.1344	+.0003
	112		
Uranus,	280	280.0496	+.0002
	112		
Saturn,	168	165.8064	—.0131
	63		
Jupiter,	105	105.2344	+.0022
	63		
Mars,	42	41.8936	—.0025

* "Statement and Exposition of Certain Harmonies in the Solar System, by Stephen Alexander, LL.D.," (Smithsonian Contributions, 280,) p. 17.

† The names of the Planets will be used to denote their *rotation-radii* throughout the present paper, unless otherwise expressly stated. The unit of rotation-radius is $\frac{1}{8}$

		Theoretical.		Actual.	Difference Ratio.
		12			
Earth,		30		30.5480	+.0183
		6			
Venus		24	12	23.9600	—.0017
		6	15		
		18			
Venus-Mercury,	12	3			
Mercury,		15		14.9913	—.0006
		3			
Half-Venus,		12	15		
	12				
Sun,		0			

The strongest asserter of accidental coincidences might well be staggered at such consistency of order, and the believer in universal causation may naturally ask how it is to be accounted for. I think an explanation may readily be found in the combined action of inertia and elasticity, the rhythm springing from the well-known law of harmonic densities, and therefore furnishing a strong indication of universal æthereal elasticity. I propose to inquire what harmonic series are most obvious in the general arrangement, and on what simpler and earlier nodal activities they all depend. The mathematical considerations which I shall introduce are such as belong to central forces in general, but my illustrations will all be drawn from gravitating action.

In a rotating nebula, the centre and the centrifugal unit at $\frac{1}{2}r$, or $\frac{7}{2}r$ if we count from the circumference, give three nodes in the proportions 7, 8, 9, which have a common harmonic numerator in $7 \times 8 \times 9 = 504$. Introducing also the harmonic node $\frac{1}{2}r = 4$, we obtain two natural harmonic series, $\frac{7}{9}$, $\frac{7}{8}$, $\frac{7}{7}$; $\frac{8}{9}$, $\frac{8}{8}$, $\frac{8}{7}$; etc. Now

$\frac{7}{9}$ of 504	= 392		♆
		112	
$\frac{8}{9}$ of 504	= 280		♅
		112	
1st sub-harmonic	168		♄
		63	
$\frac{5}{8}$ of 168	= 105		♃
		63	
2d sub-harmonic	42		♂
		12	
$\frac{5}{7}$ of 42	= 30		⊕
		12	
3d sub-harmonic	18		♀ ☿
		3	
$\frac{5}{6}$ of 18	= 15		☿
		3	
4th sub-harmonic	= 12		
$\frac{5}{8}$ of 12	= 12		
2×12	= 24		♀

Jupiter, Earth at perijove, Earth at apojove; and Earth, Sun, Venus; repeat the ratio of Uranus to the prime multiple, $\frac{8}{9}$. Comparing the corresponding pairs of inner and outer planets, we find

☿ : ♀ : : ♃ : ♄ : : 5 : 8

⊕ : ♂ : : ♅ : ♆ : : 5 : 7

thus introducing the second series, $\frac{5}{6}$, $\frac{5}{8}$, $\frac{5}{7}$.

If we measure the pendulums from Jupiter, Sun (105) is a mean proportional between Saturn (168-105) and Uranus (280-105). Moon and Venus repeat, in two phases, the limiting ratio of Neptune to Sun, 392. For, Moon's angular ve-

Sun's radius. The actual rotation-radius of each planet = (rad. vec. ÷ 18) ¾. E. g. Mercury's rad. vec. = 83.17 Solar-radii = 665.36 rotation units; (665.36 ÷ 18) ¾ = 14-.9913. If Sun was expanded to $\frac{14.9913}{5}$ of its present radius, its time of rotation would equal Mercury's time of revolution.

locities of rotation and revolution being the same, we may regard her distance as a rotation-unit; and the distance of Venus's orbit from Earth's, measured in Earth's radii, corresponds with Neptune's distance from Sun, measured in Sun's radii, (6453 at mean distance, 6518 at mean aphelion). Venus's mean distance from Earth being .27667 of Earth's mean radius vector, Sun's distance is found by dividing Venus's distance by .27667.

392 × Moon's distance		= 93,155,000 miles.
6453 × Earth's radius	÷ .27667	= 92,470,000 "
6518 × " "	÷ .27667	= 93,395,000 "

Before any physical phenomenon can take place, there must be a physical force to which it can be traced. The first step in creative development should therefore be the creation of force. The potential energy of a body represents the difference between its present, or actual energy, and the greatest energy of which it is capable. In gravitation it is often referred to the results of a possible fall from the present position to the centre of attraction. If such reference were strictly true, the potential energy would always be infinite; if it is not true, it is desirable to find at what point increase of energy must cease, and all the energy must become actual. Various essays towards this determination have been made in Electricity and Chemistry; if all force is unitary in its origin, the most encouraging field for investigation would seem to be the one in which force is manifested on the largest scale—the astronomical field.

The energy which acts with reference to the Sun as a centre, is shown in two prominent ways; in planetary revolution, the velocity of which in a circular orbit I will represent by v_{α}, and in solar rotation or retarded revolution, v_{β}. Let v_{γ} be the velocity towards which they both tend, and to which they would both be equal if all the potential energy of revolution, rotation, and internal resistance could be changed into actual energy. v_{α} varies inversely as the square root of radius, while v_{β} varies inversely as radius, so that if the potential is expressed in units of the radius at which the velocities would become equal, $v_{\beta} = \sqrt{v_{\alpha} v_{\gamma}}$; v_{β} always being a mean proportional between v_{α} and v_{γ}. This, however, is not the limit of possible energy, for the velocity communicated by infinite fall $= \sqrt{2}\, v_{\alpha}$, and a body approaching the centre with that tangential velocity would immediately recede, never to return. $\sqrt{2}\, \bar{v}_{\alpha}$* may therefore be called the velocity of dissociation.

If we suppose a circular orbit to be flattened until it becomes a linear ellipse with the solar focus at one end, the mean orbital velocity through twice the diameter $= \frac{2}{\pi} v_{\alpha}$. If shrinkage or fall continues after $v_{\beta} = v_{\alpha}$, the greater centrifugal force of rotation destroys rotation proper, giving

* The superscript line denoting the greatest velocity possible.

the particles in the equatorial plane of the nucleus orbits of increasing eccentricity, until they ultimately become linear, and, when $\frac{2}{\pi}\ \bar{v}_{\rho} = \sqrt{2}\ v_a$, the velocity of dissociation is reached, and all the energy becomes actual. This velocity, as I have already shown, is the velocity of light.

If we consider Sun as a molecule in infinite space, in a trochoidal wave-stratum, every particle alternately approaches a given point and recedes, during a half-rotation. The projectile or attractive force, at or near Sun's surface, which would give this alternate approach and retreat, may be represented by gravity acting for a half-rotation, $\frac{gt}{2}$, which would also give the velocity of light. As the time of rotation varies inversely as gravity, $\frac{gt}{2}$ has been, and will be constant, however much Sun may have been expanded or may hereafter contract.

In order that there may be such "mutual interchange of relations" as is needed for life and phenomenal change, there must be both resemblance and difference. There must be space and time, and also position, with some degree of fixity in space and time. A universally undulating, homogeneous æther, could manifest no variety, unless its undulations were in some way intercepted, and directed to definite points for definite purposes. There must be both elasticity and inertia, and differences of elasticity and inertia. In an expanded nebulous disc, with tendencies to nucleal aggregation at different points, those conditions would all be supplied. Every point of gross inertia, intercepting undulations from every direction would set up centripetal actions and centrifugal reactions, with tendencies to mutual compensations and equilibrium, which would give rise to physical forces in great variety.

In the second volume of Gould's Astronomical Journal, published in 1852, Prof. Stephen Alexander gave numerous nebular expositions, one of which treated of the Milky Way as a spiral with four branches. In the Proceedings of the Royal Astronomical Society for December, 1869, Proctor gave a paper entitled "A New Theory of the Milky Way," which also described it as being a spiral. In a paper read before the American Philosophical Society, September 20, 1872, I called attention to the following, among other facts:

"In the solar-focal parabola which passes through a Centauri and has its directrix in a linear centre of oscillation of a solar diameter, twenty-seven successive abscissas may be taken in regular progression,

$$\left[x_n = \xi^{(n^0)}\ \eta \pm^{(n^1)}\ \zeta^{(n^2)}\right]$$

between the Star and the Sun's surface, nine of which will be extra planetary, nine will be in simple planetary relations, and nine will be intra-planetary.

"The upper extra-planetary abscissa bears nearly the same ratio to the

modulus of light, as [the limit of possible solar atmosphere] bears to solar radius.

"The limiting abscissas of the planetary series are determined by combining diametral centres of oscillation ($2 \times \frac{2}{3}$), with centres of explosive condensation ($\frac{5}{3}$), and of explosive oscillation ($\frac{5}{6}$).

"The planetary series, between these limits, is $\frac{1}{2}$ ♀, $\frac{2}{3}$ ⊕, $\frac{3}{4}$ ♂, $\frac{4}{5}$ mean asteroid, $\frac{5}{6}$ ♃, $\frac{6}{7}$ ♄, $\frac{7}{8}$ ♅.

"No probable values can be assigned to the cardinal abscissas (α Centauri and $\frac{4}{3}$ L), which will produce deviations of the theoretical from the observed values of a higher magnitude than the planetary eccentricities."

A manifest connection is thus shown between our solar system and the stellar systems, the parabolic pathway, and the relations of the modulus of light both to the solar atmosphere and to the parabolic co-ordinates, suggesting an identity of undulating and harmonic influence, which extends the significance of the first creative fiat beyond the limits of our planetary sisterhood.

We have seen that $\frac{2}{\pi}\bar{v}_\beta = \sqrt{2}\bar{v}_\alpha$ is the limit of total dissociation, therefore $\frac{\sqrt{2}}{\pi} v_\beta = v_\alpha$ is the limit of possible circular revolution. Planetary v_α at Sun is 80.35 times as great as at Neptune; $\frac{\sqrt{2}}{\pi} \times 80.35 = 36.18$; therefore at 36.18 solar radii the reactionary v_β bears the same ratio to v_β at Sun's surface, as the accelerated v_α at Sun bears to v_α at the outer limit of the system. This represents a rotation-period of $25^d.2388$, corresponding very closely with the Sun-spot estimates which have been least influenced by the unexplained acceleration* of the spots near the equator, and differing by less than $2\frac{1}{2}$ per cent. from the estimate which is the most reduced by allowance for that acceleration.

The range of uncertainty is as follows:

Laugier, Bianchi, and Herschel	$25^d.3250$
"Light"-force, Theoretical	25.2388
Petersen	25.1875
Faye	25.0747
Lelambre	25.0002
Carrington	24.9711
Kirkwood	24.8259
Spörer	24.6245

Stockwell has found† that the mean perihelion longitudes of Jupiter and Uranus differ by exactly 180°, while the mean node longitudes of

* I know of no attempt at explanation but the one which I have already given, based on the hypothesis that the velocity is due to combined orbital and rotational influences.

† Memoir on the Secular Variations of the Eight Principal Planets (Smithsonian Contributions, 232) p. xiv.

Jupiter and Saturn also differ by 180°. These accordances seem to point to a primitive nebular arrangement of alternating nucleal points, as represented in the accompanying figure.

♆ 224 ♄ 168 ☉ 105 ♃ 175 ♁

If we compare the rotation-radii for Neptune's mean aphelion and Uranus, we find the ratio of velocity from infinite fall to orbital velocity; the mean radius gives us the ratio 7 : 5; Uranus : Saturn : : 5 : 3; Jupiter : Saturn : : radius of spherical gyration : radius of homogeneous mass; the difference between Uranus and Jupiter : Jupiter : : Uranus : Saturn. The four exterior planetary orbits therefore furnish the following harmonic series: $\frac{7}{7}, \frac{7}{5}, \frac{7}{3}$; $\frac{5}{5}, \frac{5}{7}, \frac{5}{3}, \frac{5}{5}$; $\frac{3}{3}, \frac{3}{5}, \frac{3}{7}$.

Having shown that the limit of equality, from or towards which the rotating and orbital velocities of a solar equatorial particle both tend, is, like the ratio of the electric units, a quantity of the same order of magnitude as the velocity of light, let us start from that velocity, and see how nearly our results agree with those already given.

Let the velocity and time of describing radius at Sun's equator be represented by

$v_\alpha, t_\alpha,$ in solar rotation;

$v_\beta, t_\beta,$ in equatorial revolution;

$v_\gamma, t_\gamma,$ by the velocity of light;

$v_\lambda =$ the velocity of light;

$$\text{Then } t_\alpha \propto r^2;\ v_\alpha = gt_\gamma = \frac{r}{t_\alpha} \propto \frac{1}{r}$$

$$t_\beta \propto r^{\frac{3}{2}};\ v_\beta = gt_\beta = \sqrt{gr} \propto \frac{1}{\sqrt{r}}$$

$$t_\gamma \propto r;\ v_\gamma = gt_\alpha = \frac{v_\lambda}{\pi},\ \textit{constant}$$

Taking Sun's radius as the unit of length, and a second as the unit of time, $v_\lambda = \frac{214.86}{497.83} = .4316\ r$ per s; $t_\beta = \frac{365.2564 \times 86400}{2\pi\,(214.86)^{\frac{3}{2}}} = 1595\ s.$; $v_\beta = \frac{r}{1595} = .000627r$; $v_\alpha = v^2_\beta \div v_\gamma = .000000911r$; time of rotation $= 2\pi r \div v_\alpha = 25.409$ *days*. The rotation-radii of the several planets, found by dividing the square roots of their orbital times by the square root of the time of solar rotation, are as follows:

Neptune	48.6693	Mars	5.1997
Uranus	34.7531	Earth	3.7915
Saturn	20.5777	Venus	2.9738
Jupiter	13.0581	Mercury	1.8607

These values, being given in solar radii, should be multipled by eight

to reduce them to the centrifugal units which are given in the first table. Making the reduction, we find that the values found by the two methods differ by less than three-quarters of one per cent.

Let us take the differences between the perihelion planets of successive two-planet groups.

Neptune	392.1344	
Uranus	280.0496	174.8152
Jupiter	105.2344	74.6864
Earth	30.5480	30.5480
Sun	0.0000	11.9800
½ Venus	11.9800	4.4844
½ Mercury	7.4956	

If we then divide Neptune by the first difference, the first difference by the second, and so on, we get the harmonic series $\frac{56}{25}, \frac{56}{24}, \frac{56}{23}, \frac{56}{22}, \frac{56}{21}$; the numerator being the quantity which is contained 9 times in the prime multiple, 7 times in Neptune, 5 times in Uranus, and 3 times in Saturn, and the greatest error in any of the theoretical denominators being less than one-half of one per cent. As the *relative* values of the rotation-radii depend on the square-roots of the orbital times, which have been determined with more precision than any other astronomical elements, these harmonies are known with great exactness.

The harmonies of which Earth forms a constituent seem, as I have repeatedly shown,* to be more numerous than those in which other planets are exclusively involved. Is it because we are best fitted for observing things with which we are most nearly concerned, or because Earth is really of more present importance and is therefore purposely provided with more various adaptations for the nurture of intelligence than either of its sister orbs, or is it for merely æsthetic reasons, the harmonies being chords in the eternal hymn of praise which ascends from every portion of the created universe to its Creator?

A new modification of the harmonic law, in the case of Venus and Mercury, is shown, not only by the fact already mentioned, that the half-radius is introduced, (as if through a renewed operation of the relations between the radii which equalize the velocity of infinite fall and circular orbital velocity), but also by the intervention of Sun, which may perhaps be taken as an additional evidence that the parabolic connection of the solar system with its proper stellar system has produced a parabolic spiral, and may therefore be regarded as a further confirmation of Prof. Alexander's views. If we suppose, in accordance with the analogies of organic development, that the orderly processes were going on simultaneously throughout the universe, we may readily conceive that the assignment of the interior planets to their appointed places was not only the completion of our own Cosmos, but that it was also synchronous with the completion of the stellar-nebular group to which we belong.

* Perhaps the most important of those harmonies may be the retention by Earth of one-half Sun's angular rotation energy; Sun's superficial gravity giving the velocity of light in a half-rotation, Earth's, in a whole revolution.

The connection of the two-planetary with the single-planet series, which adds to the general harmony the local harmony of equal differences on each side of the respective perihelion planets, is initiated by the relation of Uranus to Neptune, in other words by the simple harmonic which most nearly denotes the ratio of circular orbital velocity to the velocity from infinite fall. The repetition of the harmonic couplet, $\frac{3}{7}$, $\frac{5}{8}$, both in the Jovian and in the Telluric belt, is also a consequence of the same initiative. If we look merely to the differences between the mean and the harmonic positions, Saturn and Earth are most disturbed by the action of Jupiter, Mars has fallen slightly towards Earth, Jupiter towards Saturn, Venus and Mercury towards Sun. Even the greatest differences are less than half of the mean eccentricities, so that the harmonic positions are *exactly* represented, and traversed by each planet in each orbital half-revolution. Moreover, since the geometrical mean of the actual mean radii, differs by less than $\frac{1}{25}$ of one per cent. from the geometrical mean of the harmonic radii, the evidence of primitive harmonic influence modified by mutual perturbations, seems irresistible. Deviation within prescribed limits, allowing liberty in subordination to law, pervades all nature, and is the source of manifold supplementary harmonies and æsthetic gratifications, which would be impossible under a more rigid code.

Although the harmonic action is most simple and most striking in the rotation radii, in consequence of the greater determining influence of the nucleus, the action does not cease even after the withdrawal of all the immediate effects of nebular condensation. We accordingly find such additional rhythmical relations as are indicated by "Bode's Law," "Kirkwood's Analogy," Peirce's Phyllotactic Planetotaxy, Alexander's radial ratios, and the various accordances which I have hitherto communicated to the Society. Perhaps the most important exemplification of varied influence may be found in the mutual relations of the principal planetary masses; Neptune and Saturn being of such magnitudes as to equalize their inertia-moments near the lower nebular, or nucleal radii; Saturn and Jupiter having equal moments near the upper nebular, or vector-radii; Saturn and Uranus having equal momenta with reference to Jupiter, in the primitive arrangement of nucleal points; and Jupiter balancing Sun, in a linear pendulum, of which the geometrical mean planetary rotation radius represents a centre of oscillation, and Sun's surface represents both a centre of suspension and a fulcrum.

The first break in the Jovian belt appears to have separated the three outer planets from Jupiter, the mass of Jupiter being such as to give the same moment of inertia at a centre of spherical gyration as the remaining mass would have at the corresponding spherical surface. The outer belt subdivided in such manner that its middle planetary moment was determined by Saturn, while Saturn's was determined by Sun, the *momentum* depending on Sun, Jupiter, and Saturn, as already stated. The equality of the Saturnian and Neptunian rotation-moments completed the harmony of Chladni aggregation.

According to the latest estimates* the masses of the four exterior planets, taking Sun as the unit, are

Jupiter.....	.0009543269	Uranus.....	.0000454545
Saturn.....	.0002855837	Neptune.....	.0000507614

the aggregate being .0013361265. The distribution of the aggregate, according to the hypothesis here given, involved the following steps:— 1. The square of the radius of spherical gyration being .4, in order that mr^2 may equal $m_1r_1^2$ the masses must vary inversely as the square of radius. This gives .0009543761 for Jupiter, and .0003817504 for Saturn, Uranus, and Neptune. 2. Taking Saturn and Neptune as secondary centres of rotation for the remaining mass, and taking a nodal division midway between Saturn and Uranus, the Saturnian rotation-radius = 7.1402 solar radii, the Neptune-Uranian radius = 21.1508, and the masses varying inversely as radius, we obtain .0002854019 for Saturn and .0000963485 for Uranus and Neptune. 3. The equal moments of Neptune and Saturn requiring that their masses should be inversely as the squares of their rotation-radii, Neptune $= \left(\frac{20.7258}{49.0168}\right)^2 \times$ Saturn $=$ .0000510257, leaving for Uranus .0000453228. The closeness of coincidence is shown below:

	Theoretical.	Actual.	(T-A) ÷ A.
Jupiter	9543761	9543269	+ .00005
Saturn	2854019	2855837	— .00064
Uranus	453228	454545	— .00289
Neptune	510257	507614	+ .00521
Neptune × 49.0168^2		.12196	Theoretical
Saturn × 20.7258^2		.12267	Equality.
Jupiter × 5.2028^2		.025833	"
Saturn × 9.5389^2		.025985	
Uranus × 48.1605		.0021891	"
Saturn × 7.5715		.0021626	
Sun ÷ ⅔ Jupiter's r. vec.		.0013418316	"
Planetary Mass		.0013421925	
Uranus × 2π		.0002856	"
Saturn		.0002856	
Neptune × $\sqrt{32}$		.0002872	"
Saturn		.0002856	

I published the second theoretical equality in the 13th Volume of the Proceedings of the American Philosophical Society (p. 141), without knowing that it had ever been previously noticed, but I find, from Prof. Alexander's recent Memoir,† that he announced it to the American Association, at its Montreal Meeting, in 1857. The other nine accordances I think are entirely new. The last three introduce the following considerations:

1. If the aggregate planetary mass were at Jupiter's centre of linear oscillation, the centre of gravity of the system would be at Sun's surface.

* For authorities, see Alexander's "Statement and Exposition," p. 3.

† Op. cit., p. 38

2. Uranus is to Saturn, as the time of describing radius in a circular orbit is to the time of orbital revolution.

3. Neptune is to Saturn, as the time of describing radius in direct fall to the centre is to the time of orbital revolution.

While thus using the convenient language of the nebular hypothesis, I have looked merely to the known laws of centripetal and centrifugal forces which are now operative, without feeling bound by any special theory. Whether planetary aggregation has sprung from gaseous or vaporous clouds, or from meteoric fall, or from explosive nucleal action, or from all combined, is immaterial; in any case the equilibrating forces would be called into play, and, if they act through the intervention of an elastic medium, the law of harmonic differences should be traceable in any resulting arrangement. "Subsidence, and the central aggregation consequent on subsidence, may go on quite as well among a multitude of discrete bodies under the influence of mutual attraction, and feeble or partially opposing projectile motions, as among the particles of a gaseous fluid."*

Among the most important consequences of such conservation of force as is indicated by the gravity-potential and its relation to light-velocity, may perhaps be reckoned the provision which they seem to involve for the perpetuation of physical activity. In the common interpretations of the nebular hypothesis and of most of the modern thermodynamic theories, continual contraction and heat-radiation have been supposed to tend towards ultimate stagnation and universal death. In the almost exclusive regard which has been paid to centripetal influences, the increasing energy of the centrifugal force and its final preponderance have both been overlooked. To this general bias of speculative thought Prof. Alexander furnishes a weighty exception. In his Note on the origin of clusters and nebulæ, he refers to appearances "as if, when they were released from superincumbent pressure, by the rupture of the outer portions of the spheroid, or other primitive form, their feeble central attraction could no longer preserve them in form; and so their centres are always broken up."† In illustration of the alternating destructive and conservative changes, he closes the Note with the following words:

"For the growing leaf is fed by the exhalations which it finds in the atmosphere; and the leaf, in its decay, nourishes the vegetating tree; the roots of that tree are embedded in the *débris* of a comparatively ancient earth; the earth itself, in view of the nebular hypothesis (of Laplace), has been detached from the sun; and the sun and other stars would now seem to be but the comparatively small fragments or drops of greater masses: the one great plan pervading the *whole*, being, BY MEANS OF A PERMITTED DESTRUCTION, TO PROVIDE FOR A MORE PERFECT ADAPTATION AND DEVELOPMENT."

* Herschel, Outlines of Astronomy, § 871.

† Op. cit. p. 92.

METEOROLOGICAL OBSERVATIONS TAKEN ON THE NILE BETWEEN CAIRO AND THE FIRST CATARACT, DURING JANUARY AND FEBRUARY, 1873.

By Lieut.-Col. R. S. Williamson,

UNITED STATES CORPS OF ENGINEERS.

(*Read before the American Philosophical Society, September* 17, 1875.)

San Francisco, Cal., July 26, 1875.

To the Secretary of the American Philosophical Society :

Dear Sir :

I send you two sheets of Meteorological Observations which I made during January and February, 1873, on the Nile, thinking that they might be considered of sufficient interest to find a place among the printed Proceedings of the American Philosophical Society.

While the general character of the climate of that country is well known, I have not heard of there having been published any regular series of observations of the wet bulb from there ; and the large number of tourists who annually visit that river, the majority of whom are Americans, makes facts concerning it of more than usual interest.

I had had made in Cairo, before starting up the river, a box two feet square, four sides of which were of lattice blinds, so that the instruments, when suspended in it, were perfectly protected from the direct rays of the sun, while the wind passed freely through it. One side of the box was provided with double doors, one or both of which could be opened or closed at pleasure. The box was placed on a table on the upper deck of the boat, and securely fastened to it. The bulbs were about ten feet from the water. Usually there was an awning above. From frequent experiments I found that there was no difference between the readings of the instruments when the doors of the box were open or closed.

The principal instruments were two sensitive identical Thermometers, which read alike when the bulbs were dry. They were made by James Green, of New York, and were of the best construction. There was also a minimum Thermometer, but not of so nice a construction.

The reductions were made by means of the tables in Profession Papers of the Corps of Engineers, No. 15, a copy of which is in the library of the Society.

The boat went up the river as far as Assouan, at the foot of the first Cataract, and six degrees of latitude south from Cairo, and returned.

Yours very truly,

R. S. WILLIAMSON,

Lieut.-Col. United States Engineers.

ARACT, DURING JANUARY, 1873.

Date.	Clouds.			Winds.			Remarks.
	A.M.	2 P.M.	9 P.M.	7 A.M.	2 P.M.	9 P.M.	
Jan'y. 1	ear.	Cir. 3.	Clear.	N. 2.	N. 4.	N. 2.	Min. 40.5. Dew.
" 2	"	Clear.	"	" 1.	" 4.	" 4.	" 36.5.
" 3	"	Cir. cu. 4.	"	" 1.	0.	0.	
" 4	"	Clear.	"	S. 1.	S. 1.	0.	
" 5	"	"	"	0.	N. 2.	0	
" 6	"	Cu. st. 9.	Cir. cu. 7.	0.	N. 3.	0.	
" 7	"	Clear.	Clear.	0.	N. 3.	0.	
" 8	"	Cir. 2.	"	0.	N. 3.		
" 9	"	Clear.	"		N. 2.		
" 10	"	"	"	N. 4.	N. 5.		
" 11	"	"	"	N. 2.			
" 12	"	Cu. 1.	"		N. 2.		
" 13	"	Cir. cu. 2.	"	N. 2.	N. 1.		
" 14	"	Clear.	"	N. 3.	N. 2.		
" 15	"	"	"		N. 2.		
" 16	"	"	"		N. 1.		
" 17	"	"	"				
" 18	"	"	"				
" 19	"	"	"		N. 4.		
" 20	"	"	"				
" 21	"	"	"	N. 1.	N. 1.		
" 22	"	"	"				
" 23	"	Cir. 3.	"	N. 1.			
" 24	"	Clear.	"				
" 25	"	"	"	N. 1.			
" 26	"	"	"	N. 2.			
" 27	"	"	"	N. 1.	N. 1.		
" 28	"	"	"	S. 1.	N. 3.		
" 29	"	Cir. 7.	"				Min. 40.
" 30	. 5.	Clear.	"	N. 1.			" 41.
" 31	ear.	"	"				" 50.5.
Mean							
Feb'y 1	ar.	Clear.	Clear.	N. 1.	N. 1.	0.	Min. 46°5.
" 2	"	"	"				" 50°
" 3	"	"	"	N. 1.			" 54°
" 4	"	"	"				" 45°
" 5	"	"	"				" 45°
" 6	"	"	"	N. 1.	N. 2.		" 45°5.
" 7	"	"	"	N. 2.	N. 3.		
" 8	. 5.	Cir. 5.	Cir. 5.				
" 9	. cu. 8.	Cir. cu. 2.	0.				" 48°
" 10	. 2.	Clear.	Clear.				" 48°
" 11	ar.	"	"	N. 1.			" 48°
" 12	y.	Cir. 4.	Cir. 8.				
" 13	ar.	Clear.	Clear.				" 51°. Max. 86°
" 14	"	Cir. cu. 8.	Cir. cu. 5.	S. 1.	S. 2.	S. 2.	" 57°
" 15	. cu. 8.	Cir.cu. 10.	Cir. cu. 7.	S. 1.	N. 5.	N. 5.	" 67°
" 16	. cu. 8.	Clear.	Clear.	N. 6.	N. 6.		" 52°
" 17	ar.	Cir. cu. 3.	"	N. 2.	N. 4.	N. 3.	" 42°
" 18	"	Clear.	"		N. 4.		" 39°5.
" 19	"	Cu. st. 5.	"	N. 5.	NW 6	N. 3.	" 38°
" 20	5.	Cu. 5.	"	N. 6.	N. 5.		" 38°
" 21	ar.	Clear.	"	N. 3.	N. 4.	N. 1.	" 38°
" 22	"	"	"	0.	N. 3.	N. 4.	" 37°5.
" 23	"	"	"	N. 4.	N. 3.	N. 3.	" 48°
" 24	"	"	"				" 45°
" 25	"	Cir. 7.	"				" 43°
" 26	"	Cir. 4.	"				" 45°
" 27	"	Cir. 2.	"				
" 28	"	Clear.	"				" 46°5.
Mean							

ON GLACIAL DEPOSITS AT WEST PHILADELPHIA.

(WITH A MAP.)

By Charles E. Hall.

(*Read before the American Philosophical Society, November* 5, 1875.)

In a preceding paper on Glacial Deposits in Carbon, Northampton, and Monroe Counties, published in the Proceedings of the Philosophical Society, I proved that the glaciers passed through the gaps of the Kittatinny Mountain and followed somewhat the courses of the present river beds, at all events toward the close of their existence.

The southern boundary of the Glaciers is a question which will require much careful study to determine. It is, however, probable that they reached much further south than generally supposed, and it would scarcely be probable that a mass of ice, great enough to pass over the highest ranges of the White, Green, and Adirondack Mountains, to suddenly end at so short a distance as the Blue, or Kittatinny Mountain.

I will take this opportunity to speak of the double systems of Glacial scratches so plainly marked in the more northern country. I have observed on the shores of Lake Champlain, the polished surfaces indicating a movement of the ice in a line nearly parallel to the lake, or a southerly movement, while a few miles back from the lake, many of the valleys are crossed by moraines, which indicate Glaciers moving in an easterly and south-easterly direction towards the lake, and polished surfaces and scratches indicating the same. I concluded from this that one system of scratches indicate the course of the moving ice when it was so great as not to be influenced by the topographical features of the country. And the second system, formed after the mass had so melted away that it followed the depressions of the surface.

It is my object, in the following, to show that we have Glacial deposits within the limits of the City of Philadelphia. Since my residence in this City the *alluvial* deposit has occupied my attention. It is composed of sand, rounded quartz pebbles, and gravel, of sandstone and conglomerate. It varies in depth from two and three feet to twenty-five. Intermingled with the rounded quartz pebbles, are found everywhere, angular pieces of softer sandstone, as Medina and New Red, which would necessarily have been worn into rounded pebbles and sand had they been associated with the quartz when *it* was being formed into pebbles. The conclusion I therefore come to is this, that the quartz pebbles of this region, perhaps also, of the Atlantic coast, is the debris from the decomposition and disintegration of the older rocks as the Oneida conglomerate, coal conglomerate, etc., and brought here principally by the ice and water of Glacial time. About the first of October, I made the first critical examination of the land lying between Spruce and Walnut streets and west of Forty-fifth street, where the sand and gravel has been excavated to, or within a short distance of the bed-rock. Here are exposed

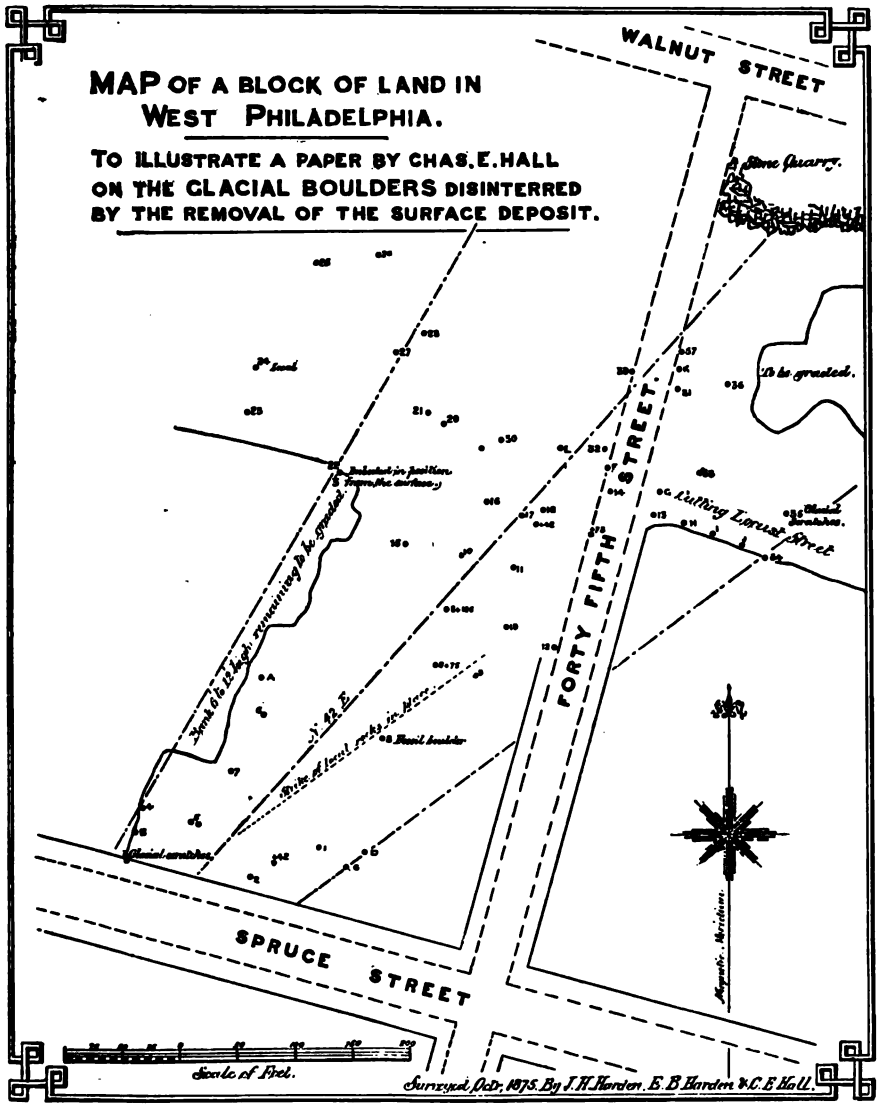
many large angular and rounded blocks of Oneida conglomerate, Medina sandstone and probably Clinton and Oriskany sandstone. These blocks vary from one or two cubic feet to twenty-five, many of them still preserving their sharp angles; on several blocks I could clearly define Glacial scratches.

Flat and angular boulders which I have observed still imbedded in their original position, are lying at different angles to the horizon. Toward the lower part of the bed of sand, gravel, and boulders, I have noticed frequently a large amount of angular and broken bed-rock or mica schist. A few boulders of Oneida and Medina just south of Pine street and west of Forty-fifth street were also observed. The average line of deposit of these large boulders is N. 42° E. or at right angles to the average course of the Schuylkill River.

In carrying this line northeastward it crosses another similar deposit between the tracks forming the Y at the junction of the P. C. R. R. and N. Y. branch, about the corner of Thirty-eighth and Hutton streets, and another more extensive deposit near Thirty-eighth street and Girard avenue. The excavation is now going on near Girard avenue, and I was enabled to see many of the larger blocks still in position; the average of these are deposited at angles to the horizon.

Among those at Thirty-eighth and Hutton streets are blocks of Oneida conglomerate and Medina sandstone. Large quantities of New Red sandstone, and a few blocks of trap rock were also observed. From all these evidences I have concluded that this belt of drift deposit is no other than a Glacial moraine, formed by the Schuylkill Glacier receding from the site of the City. It is very possible that we have here a complicated system of moraines formed as the scratches in the North by the ice at different stages of its existence. J. H. Harden, M.E., procured some specimens of conglomeratic sandrock, with casts of Spirifer which I have been unable to determine. Mr. J. C. Smith afterward obtained a specimen of Oriskany sandstone with Spirifer arenosus, from a deposit west of Forty-fifth street and north of Walnut.

I am indebted to Mr. J. H. and E. B. Harden for the accompanying map, on which they have carefully located all the principal boulders observed in the locality first mentioned. One fact I will add is, that the surface of the gneiss where laid bare is comparatively smooth, and shows evidence of having been polished, though so soft as not to retain the marks of Glaciation.


MAP OF A BLOCK OF LAND IN WEST PHILADELPHIA.
TO ILLUSTRATE A PAPER BY CHAS. E. HALL ON THE GLACIAL BOULDERS DISINTERRED BY THE REMOVAL OF THE SURFACE DEPOSIT.
WALNUT STREET
SPRUCE STREET
FORTY FIFTH STREET
Stone Quarry.
To be graded.
Cutting Locust Street
Fossil boulder
Glacial scratches
Scale of Feet.
Surveyed Octr. 1875. By J. H. Harden. E. B. Harden & C. E. Hall.

Stated Meeting, June 18th, 1875.

Present, 17 members.

Vice-President, Mr. FRALEY, in the Chair.

Letters of acknowledgment were received from the R. R. Zool. Bot. Gesellschaft, Vienna (XV, i, 90, 91); the R. Belgian Academy (XV, i, 89, 90, 91); the Imp. Austrian Acad., (XV, i, 90, 91); the N. J. Hist. S., (94).

Postal card acknowledgments of the reception of No. 94 of the Proceedings, January—June, 1875, just published and distributed, were received from the University of Toronto, Canada; J. B. Francis, Lowell, Mass.; Buffalo Social Science Ass.; U. S. Hospital, N. Y.; Astor Library; Acad. of Science, St. Louis; Chicago Historical Soc., Maine Historical S.; and from the following members: S. Alexander, Princeton, N. J.; D. G. Engleman, 3003 Locust Street, St. Louis; J. S. Haines, Haines Street, Germantown, Philadelphia; Charles Hale, 22 Ashburton Place, Boston, Mass.; C. H. Hitchcock, Hanover, N. H.; W. C. Kerr, Raleigh, N. C.; Leo Lesquereux, Columbus, Ohio; Walter H. Lowrie, Meadville, Pa.; J. S. Newberry, Columbia College, N. Y.; Robert Peter, M. D., Lexington, Ky.; Theo. C. Porter, Easton, Pa.; P. W. Sheafer, Pottsville, Pa.; Ch. M. Wheatly, Phœnixville, Pa.

Postal cards acknowledging the receipt of copies of Part 2, Vol. XV, Transactions, just published and distributed, were received from Mr. Wheatly; the New York Hospital, 8 West Sixteenth Street, N. Y.; West Point Academy; Astor Library; and New Jersey Hist. Soc, Newark.

Letters of envoy were received from the Academies at Vienna and Brussels; the Board of Commissioners of the Second Geological Survey of Pennsylvania; and Mrs. Caroline E. G. Peale, bestowing upon the Society's Library a number of elegantly bound volumes of ethnological memoirs and works from the library of the late Mr. Franklin Peale.

Other donations for the library were received from the Academy and Observatory at St. Petersburg; the Prussian Academy; German Geol. Society; Austrian Academy, and Zoo. Bot. Society; the Frankfurt Zool. Garden; the Physical Societies at Geneva and Bordeaux; Geographical Society; Anthropolog. Society, Annales des Mines, and Revue Politique at Paris; the R. Inst. of Luxembourg; the Belgian Academy and Observatory; the Congrès Internationale de Statistique; the Royal, R. Astro., and R. Geog. Societies at London; Nature; American Academy at Boston; Silliman's Journal; American Chemist; Mr. Josiah P. Cooke of Boston; the Medical News; Journal of Pharmacy; Penn Monthly, and Water Department of Philadelphia; the Commissioners of the Second Geological Survey of Pa., Harrisburg; the United States Engineer Department; Coast Survey; Peabody Institute, Baltimore; and the Zoological Society, Philadelphia.

On motion, Mr. Roberts asked to be relieved from the duty of preparing an obituary notice of the late member, Mr. John Henry Towne, and that Prof. Lesley be substituted in his place; which, on motion, was so ordered.

A communication "on the Geological relations of the Lignitic Groups," by J. J. Stevenson, was read by the Secretary.

Prof. Cope read a communication on an exploration of Architectural Remains on and near the Eocene Plateau of Northwestern New Mexico.

Dr. Genth communicated the corrections of an error in his recent paper On Tellurian Minerals, and announced some novel and interesting indications recently found by him in some of the minerals there described.

Dr. Cresson read a communication on the influence of magnetic forces upon iron and steel under strain.

Prof. Chase made some remarks in continuation of the subject of Dr. Cresson's paper.

Dr. Cresson offered the following resolution which was unanimously adopted.

Resolved, That the thanks of the Society be presented to Mrs. Caroline E. G. Peale, for her liberal and welcome contribution to the library of the Society of books belonging to her late husband, Mr. Franklin Peale.

Mr. Roberts called the members' attention to the improvements that had been made by the Hall Committee.

Pending nominations 780, 781, 782, were read.

And the meeting was adjourned.

Stated Meeting, July 16th, 1875.

Present, 3 members.

Dr. C. M. Cresson, in the Chair.

A letter was received from Dr. D. Renard, V. P. Soc. Nat., Moscow, June 19th, 1875, concerning the semi-centennial of the doctorate of M. Alex. Fischer de Waldheim, Pres. S. N. M., which, on motion, was referred to the Board of Officers.

A letter was received from Mr. Edward Thornton, British Ambassador at Washington, June 30, 1875, respecting the next Albert Medal of the Society of Arts, which, on motion was referred to the Board of Officers.

Letters acknowledging receipt of Proceedings No. 94 were received from Col. Williamson, San Francisco; the New York Historical, and 78 other Societies and members, by postal cards returned and signed.

Acknowledgments of the receipt of the Transactions, Vol. XV, part 2, were received from the New York Hist. Soc. by letter, and 22 other Societies and subscribers, by postal cards.

Acknowledgments of the receipt of packages of back Proceedings, due since election, were received from Col. Williamson, (81 to 92); Prof. Traill Green (81 to 92); Miss Maria Mitchell (81 to 92); Prof. C. H. Hitchcock (81 to 82); Prof. Trowbridge (86 to 92); Mr. Dupont (86 to 92); Prof. Abbe (86 to 92); Prof. Kerr (86 to 92); Mr. Haupt (86 to 92); Dr.

Peter (86 to 92); and Mr. Rothermel (92); the Providence Franklin Society (93); Philadelphia Numismatic Society (93), and Prof. Henry (93).

Donations for the Library were received from the Observatories at St. Petersburgh and Barcelona; the Academy at Berlin; the Met. Inst. at Vienna; J. Korosi, of Pesth; the Society at Bremen; Nouvelles Mèt. and Revue Politique at Paris; R. S. at Tasmania; Astron. Geog. and Chem. Societies at London; Victoria Institute; Nature; Essex Institute; Boston S. N. H.; U. S. Postal Guide; Am. Journal Science and Art; Yale College; New York Lyceum N. H.; Astor Library; Philadelphia Academy Natural Sciences; Franklin Inst.; American Journal Medical Sciences; News and Library; Journal of Pharmacy; Penn Monthly; U. S. Engineer Department, and the St. Louis Western.

The death of Sir W. E. Logan at London, June 28th, 1875. age 77, was announced by the Secretary.

Dr. Cresson communicated the result of further experiments on the influence of magnetic force on the tensile strength of iron and steel. He announced the fact as new that in the aerial magnet, or zone of magnetism in the empty space within the coil, there is a considerable elevation of temperature.

Prof. Lesley communicated the recent discovery by Mr. Ashburner, aid on the survey of the State, that the White Catskill (Vespertine Sandstone of Mr. Rogers) No. X is a true coal-measure formation, 19 distinct coal beds having been counted, one of which is one foot thick and appears to be persistent, for a similar bed outcrops in a gap a few miles distant. These beds were cut in the tunnel of the East Broad Top Railroad through Sideling Hill in Huntingdon County, Pennsylvania. This discovery explains the Peak Mountain coal-measures below the red shale in Wythe County, Virginia, as well as the presence of coal-beds in the Upper Devonian on the Potomac, and of coal-beds about 700 feet below the Millstone Grit (conglomerate No. XII) in the Allegheny mountain ravines back of Tipton and Ty-

rone in Blair County, Pennsylvania. It has nothing to do with the still older coal measures in the Lower Devonian on the Juniata river in Perry County, Pennsylvania.

On motion, the Laws of the Society were ordered to be re-printed.

Pending nominations Nos. 780, 781, 782, and new nomination 783, were read. On motion, No. 781 was postponed on account of the absence of nominees. Nos. 780, 782 were balloted for, and the following were declared duly elected members of the Society:

Dr. Thomas M. Drown, Professor of Chemistry in Lafayette College, Easton, Pa.

John L. Campbell, LL.D., Professor of Mathematics in Wabash University, Indiana, and Secretary of the United States Centennial Commission.

And the meeting was adjourned.

Stated Meeting, August 20th, 1875.

Present, 8 members.

Vice-President, Mr. FRALEY, in the Chair.

The death of the Hon. Horace Binney, the oldest member of the Society, and the oldest and only surviving graduate of Harvard College of the last century, at his residence, in Fourth street, Philadelphia, August 10, 1875, aged 95 years, was announced by Mr. Fraley.

The death of Mr. William E. Whitman, in Philadelphia, August 27th, 1875, aged 74 years, was announced by Mr. Fraley.

On motion, Judge Hare was appointed to prepare an obituary notice of Mr. Binney.

On motion, Mr. Ed. E. Law was appointed to prepare an obituary notice of Mr. Whitman.

Mr. Gabb presented a communication On the Indian Tribes and Languages of Costa Rica.

Dr. König read a paper On the occurrence of Perowskite at Magnet Cove, Arkansas.

Mr. Chase communicated notes on the Signal Service weather maps, and on newly-discovered planetary harmonies.

The minutes of the last meeting of the Board of officers and members in council were read.

Nominations Nos. 781 and 783 were read.

Mr. Fraley announced that he had received the quarterly interest on the Michaux legacy, due July 1st, last.

The meeting was then adjourned.

Stated Meeting, September 17th, 1875.

Present, 15 members.

Vice-President, Mr. FRALEY, in the Chair.

Letters accepting membership were received from Dr. Thomas M. Drown, Lafayette College, Easton, Pa., July 23d, and Prof. J. L. Campbell, Centennial rooms, Philadelphia, July 31st, and a carte-de-visite from Mr. Birch, in a letter from the British Museum, London.

Letters of acknowledgment were received from the R. A. d. Lincei, Rome, Dec. 8 (XV, i, 90, 91); the New York Hist. Soc., June 18th (XV, ii, 94); the U. S. Naval Obs., Washington, July 23d (XV, ii); the Victoria Institute, London, July 6th (93); the Statistical Society, London, July 19th (93); the Leeds Philos. and Lit. Society, July 14th (93); the Society of Antiquaries, London, August 4th (93); the R. A. S., Lisbon, July 22d (XV, i, 90, 91, 93); the N. H. S., Northumberland, New-Castle-on-Tyne, August 31st (94); the R. Geog. Society, London, July 20th (62, 88, 93 to complete its set); the Verein für Vaterl. Naturkunde at Stuttgart, Nov. 24th, 1874 (92, 93). Dr. Krauss, librarian, writes that a complete set can be sent only in exchange for a complete set.

Postal card acknowledgments of the receipt of Proceedings were received from Mr. Birch, London (81 to 91), and from various corresponding Societies and members.

A letter of envoy was received from the Netherland Botanical Association, per Mr. W. Hunter, Ass. Sec. Dep. State, Washington, August 4th, 1875.

A postal card circular was received from the Society of Biblical Archæology, London.

Donations for the Library were received from the Academies at Berlin, Copenhagen, and Brussels; the Geographical Society at Paris; Revue Politique; MM. l'abbe Ducroix and Arcelin, at Macon; Nouvelles Mètèorologiques; San Fernando N. Observatory; Meteor. Office; London Nature; Rev. O. Fisher, of Cambridge, England; Silliman's Journal; Prof. R. Pumpelly; Prof. O. C. Marsh; Prof. E. D. Cope; Dr. J. S. Newberry; Prof E. B. Andrews; Prof. E. T. Cox; Boston N. H. S.; Franklin Institute; Journal of Pharmacy; Penn Monthly; M. H. Y. Louderbach; Medical News; Mr. Trantwine; Dr. Ellicott Cowes; American Chemist; Buffalo Nat. Hist. Society; Argentine Observatory and Meteorological Office; and from the University of California.

Lieut. Col. R. S. Williamson communicated by letter, dated San Francisco, July 16th, Meteorological Observations taken by himself on the Nile during January and February, 1873.

Mr. Chas E. Hall communicated, through the Secretary, Notes on Glacial action along the Kittanning or Blue Mountain, in Carbon, Northampton, and Monroe Counties, Pennsylvania.

Prof. P. E. Chase read a communication On the beginnings of Development.

Prof. Sadtler communicated his recent researches in the laboratory of the University On the Molecular Structure of Glyceric acid.

Mr. Briggs expressed certain fundamental views in Meteorology, and announced his intention of communicating at

a proper time the results of exact calculations of the influence of evaporation on the circulation of the atmosphere and the production of storms.

The minutes of the last stated and special meetings of the Board of Officers and Council were read.

Pending nominations Nos. 781 and 783 and new nomina tions 784 to 790 were read.

And the meeting was adjourned.

Stated Meeting, October 1st, 1875.

Present, 13 members.

Secretary, Dr. LE CONTE, in the Chair.

Letters of acknowledgment were received from the R. Observatory at Brussells, August 9th (93); and the Rantoul Literary Society (94).

Letters of envoy were received from the Geological Bureau of Sweden, October 27th, 1874; the Observatory at Batavia, June, 1872; the Meteorological office, London, August and September, 1875; and the U. S. Department of the Interior.

A letter was received from the B. and C. Masonic Academy, Milton, Florida, soliciting books.

A letter declining his appointment to prepare an obituary notice of Mr. Whitman, but offering assistance to any one preparing such a memoir, was received from Mr. E. E. Law, Philadelphia, September, 24th, 1875.

Donations to the Library were received from the R. and I. Academies at St. Petersburgh, Copenhagen, and Berlin; the Geological Societies at Vienna, Berlin, and Dresden; the Geological Bureau at Stockholm; the Observatories at St. Petersburgh, and Batavia; the Societies at Ulm, Bordeaux, and Batavia; the Antiquarian Societies at Copenhagen and Worcester; Herr Rütimeyer of Basel; the Anthropological Society; Ecole des Mines, Revue Politique, and

Nouvelles Mètèorologiques at Paris; the London Chemical and Geographical Societies; Victoria Institute and Nature; the R. Cornwall Polytechnic Institute; the L. and H. Society at Quebec; Mr. Putnam, of Salem; Prof. H. H. Newton; and Silliman's Journal; the College of Physicians and Penn Monthly, of Philadelphia; The Louisville Printing House for the Blind; St. Louis Western; Mexican G. and S. Society; and the Smithsonian Institute.

The death of Dr. I. A. Lapham, at Milwaukee, September 4, 1875, age —, was announced by the Secretary, with remarks by Dr. Le Conte.

On motion, Dr. Brinton was requested to learn by correspondence with Dr. Philip Valentini of Mexico, more fully, the probable value of his memoir on the Aztec Calendar Stone. Dr. Brinton communicated to the Society the fact of Dr. Valentini's new interpretation of the stone in a historical sense, as opposed to the astronomical interpretation of Humboldt, Gallatin, and Gama, and that his MSS. would make about eighty pages of the Transactions, with illustrations; and that Dr. Valentini would be pleased to have it submitted to a committee of examination.

Pending nominations Nos. 781, 783 to 790, and new nomination, No. 791, were read.

And the meeting was adjourned.

Stated Meeting, October 15th, 1875.

Present, 17 members.

Vice-President, Mr. Fraley, in the Chair.

Letters of acknowledgment were received from the Academia dei Lincei at Rome, and Linnæan Society, London, August 25th, (92, 93).

Donations for the Library were received from F. W. C. Trafford, of Zurich; the French Geographical Society and Revue Politique; the Linnæan Society, London Nature, and

Meteorological Committee; the Boston Natural History Society, Industrial Aid Society, and the Rev. Jas. F. Clarke; the New York Historical Society and American Chemist; the Mayor of Philadelphia, Franklin Institute, Journal of Pharmacy, Medical News and Journal; the Historical Society of New Jersey; and the Engineer Department of the United States Army.

A letter being read from Judge Clark Hare declining to prepare an obituary notice of Horace Binney, and proffering aid to any one preparing such a notice, it was, on motion of Mr. E. K. Price,

Resolved, That the Society concur with the Philadelphia Bar in requesting Judge Wm. Strong to prepare an obituary notice of the late Horace Binney.

On motion, Mr. Edward Hopper was requested to prepare an obituary notice of Mr. Whitman.

Prof. Chase communicated an additional co-ordination of the ratio of heat under constant pressure to heat under constant volume.

Mr. Lesley gave a preliminary notice of the recent discovery by Mr. Charles E. Hall, of sub-angular blocks of large size, lying on the surface and in gravel, at the new cutting of Locust Street in West Philadelphia beyond Forty-fourth Street. Some of these blocks seem to be from the outcrops of the Laurentian gneiss at Reading or Easton; others of Oneida Conglomerate from the Delaware or Schuylkill water-gaps, 70 miles distance; and one was afterwards found by Mr. J. H. Harden of the University of Pennsylvania, carrying hundreds of fossil shells, from the lowest Devonian outcrops a few miles still further north.

Mr. Lesley said that Prof. Houpt, of the University, had kindly promised to survey the locality so as to place all the data on record, before the destruction of the stones by the rapid improvements of that part of the city area, and when this is done a further report would be made to the Society.

If we are to look on these blocks as moraine, it would but extend the glacial phenomena recently noticed in and in

front of the Lehigh and Delaware Water-Gaps, as far south as Allentown, over the South Mountain, and across the Trias plain, to the mouth of the Schuylkill.

Mr. E. K. Price suggested the possibility of iceberg carriage, and should prefer that explanation.

Dr. LeConte said that the agencies were allied.

Mr. Lesley replied that if the iceberg was broken from the glacier as it passed through the gaps, it is hard to see how it could pass the barrier of the South Mountain, unless it was very small and followed substantially the present river valleys. But it was too recent a discovery to justify much discussion.

Pending nominations 781, 783 to 790 were read, discussed and balloted for.

Pending nomination 791 was again read.

After scrutiny of the ballot boxes the following gentlemen were declared duly elected members of the Society:

Dr. Stephen Smith, of New York, President of the American Public Health Association.

Mr. William Blasius, of Philadelphia.

Mr. Gideon E. Moore, of Jersey City, Chemist of the Passaic Zinc Works.

Mr. Furman Sheppard, District Attorney for the City of Philadelphia.

Mr. Russell Thayer, Jr., Superintendent of the Fairmount Park, Philadelphia.

Mr. G. Clark Maxwell, F.R.S., Professor of Experimental Physics, Cambridge, England.

Mr. Charles E. Hall, of Philadelphia, Palaeontological Assistant of the Second Geological Survey.

Mr. John F. Carll, of Pleasantville, Venango County, Pa., Assistant on the Second Geological Survey.

Mr. Andrew Sherwood, of Mansfield, Tioga County, Pa., Assistant on the Second Geological Survey.

And the meeting was adjourned.

Stated Meeting, November 5th, 1875.

Present, 12 members.

Vice President, Mr. FRALEY, in the Chair.

Letters accepting membership were received from Mr. Russell Thayer, dated Fairmount Park, Phila., Oct. 19th; from Dr. Stephen Smith, dated Amer. Pub. Health Association, New York, Oct. 20th; Gideon E. Moore, Ph.D., dated Passaic Zinc Works, Jersey City, Oct. 21; Wm. Blasius, dated Phila., Oct. 25th; John F. Carll, dated Pleasantville, Oct. 27th, and Mr. Furman Sheppard, Philad'a, Oct. 28th, 1875.

A letter was received from M. Renard, of Moscow, acknowledging the letter of congratulation voted July 16th

Letters of acknowledgment were received from the R. Geog. Society, London, Oct. 23d, (Tr. XV, ii; 94; wants all Vol. XIII and XV, ii.); Astronomical Society, London, (XV, ii, 94); R. Observatory, Greenwich, Oct. 22 (94); B. S. N. H., Oct. 25th (XV, i, 91, 92, 93).

A letter asking for Proceedings No. 88, was received from the Philosophical Society of Glasgow.

A letter concerning that part of the will of the late Mrs. Caroline E. G. Peale, concerning her husband's cabinet of antiquities, was received from her executor, Mr. Robert Patterson, and at a subsequent stage of the proceedings, was, on motion, referred for consideration and report to the Curators.

Donations for the Library were received from the R. Prussian and Belgian Academies; the Societies at Lausanne and Leyden; the Geog. Society, Nouvelles Mèt. and Revue Politique, at Paris; London Nature; B. S. N. H.; Mr. Scudder, and Mr. Hyatt, of Boston; Penn Monthly; American Journal of Pharmacy; Smithsonian Institute, and the Western.

The death of Dr. Kingston Goddard, at his residence on Staten Island, Oct. 14, aged 62, was announced by Mr. Fraley.

Mr. C. E. Hall exhibited specimens from boulders in West Philadelphia, and specimens from outcrops in and behind the Blue (Kittanning) Mountain, to enable the members to compare and identify them. He exhibited, also, a local map on which each boulder was exactly placed and numbered. In the collection was one piece of trap, and several of Trias sandstone. The rest were Oneida conglomerate, and Oriskany sandstone (conglomerate). Mr. Hall expressed his conviction that most of the Philadelphia gravel was merely disintegrated conglomerate the pebbles of which had been set free in their original rolled state and not re-rolled to any extent. Many pieces were flat and yet in an erect attitude, showing ice rather than water transit. The trend of the belt of boulders, so far as studied, was roughly at right angles to the bed of the Schuylkill at the Zoological Garden. Mr. Hall had noticed a sort of smoothing off of the surface of the upturned mica schist country. In some cases the boulders were of large size, and grooved as well as polished. One of them contained many Silurian fossils.

Mr. Price invited Mr. Hall's attention to quantities of boulders being uncovered in the sand cuttings at 25th street and Fairmount avenue, on the eastern side of the Schuylkill.

In the discussion which ensued the possibility of iceberg action and the existence of gravel mounds across the interior valleys were brought into view.

Prof. Frazer wished to record the fact that he had met with considerable numbers of glaciated (grooved) pieces of Rogers' jasper-rock, Hunt's orthophyre, or as he preferred to call it, felsite porphyry rock of the South Mountain, along the low pass (partly a gorge) through which the Gettysburg-Chambersburg road leads. He suggested, for a cause, a thin glacier coming across from the Path Valley, west of Chambersburg.

Mr. Lesley described Mr. John Harger's (of Oxford, Conn.) method of obviating parallax in reading the vernier on the dial plate of a transit instrument or surveyor's compass; viz.

by using two verniers, one inside and one outside the graduated circle. If the observer finds a parallax error between the outside vernier and the scale, he will find *twice* that error between the scale and the inside vernier, and can thus easily correct his observation.

Mr. Cope offered the following resolution, with appropriate remarks:

Resolved, That the American Philosophical Society recommend to the attention of Congress the proposed scientific exploration of the River Beni of Bolivia and the adjacent regions, by Prof. James Orton, believing that the intrinsic importance of the object, as well as the experience of Prof. Orton, render it deserving of aid from the Government of the United States.

The resolution was passed, with instructions to the Secretaries to transmit copies of it to the Senate and House of Representatives of the United States, and to Prof. Orton.

Mr. Fraley reported that he had received the quarterly interest of the Michaux Legacy Fund, due Oct. 1st last.

The Minutes were then read and the meeting was adjourned.

Stated Meeting, November 19th, 1875.

Present, 12 members.

Vice-President, Mr. FRALEY, in the Chair.

A letter accepting membership was received from Mr. Charles E. Hall, dated Philadelphia, Nov. 13th, 1875.

A letter acknowledging receipt of diploma was received from Mr. James Freeman Clarke, Jamaica Plains, Mass.

Letters acknowledging receipt of Proceedings and Transactions were received from the Observatory at Munich, July 9 (92, 93); the Royal Society at Göttingen, June (92, 93); the Academy at Lisbon, Oct. 14, 1875 (92); the Statistical Society, London, Nov. 4 (XV ii, 94); and Trübner & Co., London, Nov. 3 (88).

Donations for the Library were reported from the Societies at Moscow and Liège; Geographical Society and Revue

Politique at Paris; Astronomical, Geographical, Asiatic, and Antiquarian Societies, and Editors of Nature, London; Rev. O. Fisher; Boston Society of Natural History; Mr. Samuel Batchelder; Yale College, and Professor Marsh, New Haven; Franklin Institute, Medical News, and Board of Public Education, at Philadelphia; Library of Congress, War Department, and Engineer Department, at Washington; Buffalo Society of Natural Sciences; and Editors of the Western.

Dr. Le Conte announced that he had been engaged for the past three years, and Dr. Horn for the past eighteen months, on a revision of the Rhyncophora of the United States. The memoir will make from 500 to 600 printed pages of the Proceedings. On motion a committee was appointed consisting of Dr. Leidy, Mr. C. E. Hall and Mr. Lesley, to whom it was referred.

Mr. Lesley called attention to the valuable papers on glacial drift at Washington and Richmond, read before the Boston Society of Natural History, last Spring, by Prof. W. B. Rogers.

The minutes of the last meeting of the Board of Officers and Council were read.

Pending nomination No. 791 was read.

On motion, it was

Resolved, That the Society accept the bequest of Mrs. Caroline E. G. Peale under the conditions expressed in the communication of Mr. Robert Patterson, executor.

On motion, it was

Resolved, That until otherwise ordered by the Society, this collection be deposited in the office of the Philadelphia Saving Fund Society, and the Curators be authorized to make arrangements with said Society for its safe keeping.

On motion, it was

Resolved, That, upon the recommendation of the Board of Officers and Members in Council at its last meeting, the edition of the Proceedings be increased from 750 to 1250 copies; and that the Librarian be authorized to sell copies at 50 per cent. above the actual cost price of publication.

The meeting was then adjourned.

The Letter of Mr. Robert Patterson referred to above.

329 CHESTNUT STREET,
PHILADELPHIA, October 30, 1875.

Dear Sir:—I beg leave to communicate through you to the American Philosophical Society the following extract from the will of the late Mrs. Caroline E. G. Peale, viz:

"I give to the American Philosophical Society held at Philadelphia for Promoting Useful Knowledge, the collection of relics illustrative of the Stone Age, with the descriptive catalogue thereof made by my beloved husband Franklin Peale, in trust to preserve the same as a separate collection within the Hall Building of the Society, or in some suitable place, and open to the inspection of all visitors, under such regulations as may be proper for the security thereof; the collection to be designated so as to distinguish the object and the name of the Collector as follows:

"Implements of the Stone Age from various parts of America, Europe, Great Britain, and the British Isles, collected and arranged as impressively confirming the unity of the Human Race, by Franklin Peale."

"Provided that said collection shall not be placed within the building of said Society until the same shall be fire-proof, and until then or thereafter, if deemed expedient by said Society, the collection shall be deposited in such fire-proof building, public or private, as they may designate. And if said Society shall decline or neglect the trust imposed on them, I direct my Executor to see to the execution thereof in such manner as to provide a place of secure deposit for the collection, open to the inspection of visitors; and in case of his death or disability, I request that the proper court will direct and take care of the due execution of this trust."

The character and value of this collection are known to some of the members of the Society, and were fairly exhibited in the "Memorial Volume," embracing photographs and descriptive matter, which was some two years since submitted for inspection.

The collection at present is deposited in the building of the Philadelphia Saving Fund Society, and I presume can remain there awaiting the orders of the Society and myself. The specimens are carefully packed, and at the proper time can readily be arranged in the cases. The Society, if accepting the trust, will be put to no expense in the arrangement or labelling of the collection, or for the collateral inheritance tax on the same.

As the conditions of the bequest require, among other things, that the collection shall be only placed in a fire-proof building, with which at this time the Society is not provided, the designation of a suitable place will have to be determined by the Society at its convenience.

Very respectfully yours,

[Signed.] ROBERT PATTERSON,
Executor of Caroline E. G. Peale.

DR. GEO. B. WOOD, President of the American Philosophical Society, Philadelphia.

FURTHER DYNAMIC CO-ORDINATIONS.

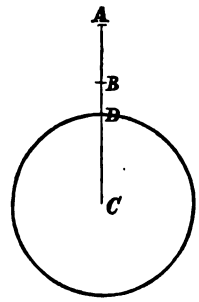
By Pliny Earle Chase,

Professor of Mathematics in Haverford College.

(*Read before the American Philosophical Society, October* 15, *and December* 3, 1875.)

A further extension may be given to my co-ordination of the great natural forces, by means of the thermodynamic relations which subsist between constancy of pressure and constancy of volume.

In central forces, varying inversely as the square of the distance, a perpetual oscillation through a linear ellipse AC, with foci at the centre of a circle and at $2r$, would be synchronous with a perpetual revolution around the circle. The complete linear-elliptical orbit being $= 2d$, the mean velocity of linear oscillation, or the velocity of constant mean gaseous pressure $= \frac{2}{\pi}$ of the velocity of revolution; a velocity which would be attained, both in the centripetal and in the centrifugal phase of the oscillation, at $1.4232r$ $\left[=\frac{2\pi^2 r}{\pi^2+4}\right]$. The ratio of heat under constant volume to heat under constant pressure, as experimentally determined, is 1 : 1.421.*



Let ρ = radius of a gaseous nucleus which is sufficiently condensed to allow of chemical combinations, or the radius of constant volume; r = radius of constant mean pressure. The *vis viva* of free revolution in a circular orbit varying inversely as radius, the ratio of the mean nucleal and atmospheric forces may be represented by the proportion

$$\rho : r :: 1 : 1.4232$$

In elastic media, as the distances from the centre increase in arithmetical progression, the densities decrease, in geometrical progression if the central force is constant, in harmonic progression if the central force varies according to the law of inverse squares. Whatever may have been the beginnings of cosmo-taxis, whether through nebular condensation, meteoric accumulation, explosive rupture, or other unknown process, the secular mean actions and reactions between opposing forces should lead to similar numerical and harmonic results. In the language of Herschel,† "Among a crowd of solid bodies of whatever size, animated by independent and partially opposing impulses, motions opposite to each other *must* produce collision, destruction of velocity, and sub-

* Tyndall, *Heat a Mode of Motion*, 4th Ed., Sect. 74.

† *Outlines of Astronomy*, Sect. 872.

sidence or mean approach towards the centre of preponderant attraction; while those which conspire, or which remain outstanding after such conflicts, *must* ultimately give rise to circulation of a permanent character."

In the earliest stages of nucleal aggregation, when the primitive oscillating velocity subjects all particles to nearly equal impulses from every direction, but with a slight preponderance towards special nucleal centres, the variation from constancy of force may be so slight as to introduce a geometrical progression based on the above thermal ratio, 1 : 1.4232. Since the *nucleal* radius of a Sun which would rotate synchronously with planetary revolution varies as $\sqrt{t}$, while the planetary radius-vector, or radius of *possible nebular atmosphere*, varies as $(t)^{\frac{2}{3}}$, the atmospheric radius varies as (nucleal radius)$^{\frac{4}{3}}$. We have thus a basis for the geometrical series, $r, r^{\frac{4}{3}}, r^{\frac{5}{3}} \ldots r^{n}$. Now $1.4232^{\frac{4}{3}} = 1.6009$, or almost precisely the fundamental radius (1.6007) which Professor Alexander has pointed out in the arrangement of the Jovian system.*

It is also very nearly represented in the ratios between the nucleal radii of the inner pairs of planets, of the two principal planetary belts; ♀ : ☿ = 1.598; ♄ : ♃ = 1.576.† The next term of the series is $1.4232^{\frac{7}{3}} = 1.8008$, which is remarkably coincident, both with Professor Alexander's fundamental ratio‡ for the solar system (1 : 1.8), and with the "centre of explosive oscillation," or the linear centre of oscillation between a primitive centre of oscillation and a linear centre of gravity ($\frac{5}{9}$ and $\frac{4}{9}$). If the involution is carried to the fifth quadrangular pyramidal number, $1.4232^{35} = 231390$, which is within less than three per cent. of the half-modulus of light at Sun's surface, measured in solar radii. The pyramidal exponent, 35, is also within less than three per cent. of the possible solar atmosphere measured in solar radii; within less than five per cent. of the half-modulus of light measured in Neptunian vector-radii; and within less than three per cent. of the nucleal radius of a nebulous Sun which would rotate in a year of Uranus.

If these accordances are dependent upon the mutual interactions of the five principal masses in our system (☉, ♃, ♄, ♅, ♆), we may reasonably look for still further accordances between the products of masses, which enter as factors into expressions of joint gravitating action. We accordingly find the following equation between the triangular powers of planetary masses, designating mean perihelion, mean, and mean aphelion, by subscript figures 1, 2, 3, respectively: $\left[\frac{♆_3}{♄_2}\right]^1 \times \left[\frac{♅_3}{♄_2}\right]^3 \times \left[\frac{♃_3}{♄_2}\right]^6 = 1$;

* *Statement and Exposition of Certain Harmonies in the Solar System* (Smithsonian Contributions, 280), p. 15.

The simple ratio, 1.4232 is approximated in the nucleal radii of the outer pairs; ♂ ÷ ⊕ = 1.372 : ♆ ÷ ♅ = 1.4.

‡ *Op. cit.*, p. 4. I am informed by Prof. Alexander that he announced this ratio before the American Association in 1857.

or, if we introduce all of the five great masses:

$$\left[\frac{\Psi 3}{\odot}\right]^1 \times \left[\frac{\hat{\odot} 3}{\odot}\right]^3 \times \left[\frac{\mathcal{U} 3}{\odot}\right]^6 = \left[\frac{\text{ħ} 2}{\odot}\right]^1 \times \left[\frac{\text{ħ} 2}{\odot}\right]^3 \times \left[\frac{\text{ħ} 2}{\odot}\right]^6$$

There is still so much uncertainty as to the masses of Neptune and Uranus, that it is impossible to tell how close this agreement may be, but the deviation from precise accuracy cannot be large. According to Newcomb's latest determinations of those masses, the equation gives two values for Saturn, one of which is slightly larger, the other slightly smaller, than Bessel's value. By looking a little further we may find relations which can be measured with greater certainty, and are therefore more satisfactory.

La Place found that if the mass of each planet be multiplied by the product of the square of the eccentricity and the square root of the mean distance, the sum of all the products will always retain the same magnitude; also, that if each of the masses be multiplied by the product of the square of the orbital inclination and the square root of the mean distance, the sum of the products will always remain invariable. Now the square root of the mean distance varies inversely as the velocity of circular revolution at the mean distance, or inversely as the square root of the velocity of nucleal rotation at the same distance. It is therefore probable that the primitive undulations may have influenced the relative positions as well as the relative masses of the principal planetary orbs. Stockwell has found* the following relations:

I. *The mean motion of Jupiter's perihelion is exactly equal to the mean motion of the perihelion of Uranus, and the mean longitudes of these perihelia differ by exactly* 180°. II. *The mean motion of Jupiter's node on the invariable plane is exactly equal to that of Saturn, and the mean longitudes of these nodes differ by exactly* 180°.

I have already had frequent occasion to refer to the position of the nebular centre of planetary inertia $\left(\sqrt{\frac{\Sigma mr^2}{\Sigma m}}\right)$ in Saturn's orbit. If the four great planets were ranged in a line, Jupiter on one side of the Sun and the other planets on the other, the tidal influences, when Saturn was in mean position, would drive Jupiter, Uranus, and Neptune to, or towards, their respective aphelia. Those positions would accord with Stockwell's two theorems, they would approximate the centre of inertia very closely to Saturn's mean radius vector, and they would make the equation of the products of triangular powers applicable to vector radii, as well as to masses. For the logarithms of mean vector-radii of the four outer planets, according to Stockwell,† are :—

Neptune, *mean Aphelion*,		1.481951	Neptune,	1.481951
Uranus,	"	1.301989	(Uranus)^4	3.905967
Jupiter,	"	.734588	(Jupiter)^6	4.407528
				10)9.795446
Saturn, *mean*,		.979496	Saturn,	.979545

* *Memoir on the Secular Variations of the Elements of the Orbits of the Eight Principal Planets* (Smithsonian Contributions, 232), p. xiv

† *Ibid.* pp. 5, 38.

The difference between the actual value of log. ♄ *r. vec.*, and the value as found by the foregoing equation, $♆ \times ♁^3 \times ♃^6 = ♄^{-10}$, is therefore, only .000049, representing a numerical difference of only $\frac{1}{50}$ of one per cent.

When the hypothetical nebular condensation had proceeded so far as to show the controlling planetary influence of Jupiter's mass, the mean perihelia of Saturn and Uranus were so fixed as to establish the following relationships of harmonic powers:

$$\left[\frac{♆_3}{♁_1}\right]^{\frac{1}{3}} \times \left[\frac{♁_3}{♄_1}\right]^{\frac{1}{2}} \times \left[\frac{♃_3}{♄_2}\right]^{\frac{1}{1}} = 1; \quad \left[\frac{♆_2}{♁_1}\right]^{\frac{1}{3}} \times \left[\frac{♁_3}{♄_1}\right]^{\frac{1}{2}} \times \left[\frac{♃_2}{♄_1}\right]^{\frac{1}{1}} = 1$$

Stockwell's logarithmic values are:

Neptune,	$♆_3$	1.481951 α	$♆_1$	1.473327	α^1
Uranus,	$♁_1$	1.262996 β			
"	$♁_3$	1.301989 γ			
Saturn,	$♄_1$	.957973 δ	$♄_2$	.979496	δ^1
Jupiter,	$♃_3$	.734588 ε	$♃_2$	.716237	ε^1

$\frac{1}{3}(\alpha-\beta) + \frac{1}{2}(\gamma-\delta) + (\varepsilon-\delta^1) = .000085 = \log. 1.0002$

$\frac{1}{3}(\alpha^1-\beta) + \frac{1}{2}(\gamma-\delta) + (\varepsilon^1-\delta) = .000382 = \text{"} \; 1.0009$

The theoretical differ from the actual values, by less than $\frac{1}{50}$ of one per cent. in the first, and by less than $\frac{1}{11}$ of one per cent. in the second equation.

At the hypothetical limit of struggle between opposing forces, which we are now considering, I have shown that the ratio between the velocity of incipient dissociation and the velocity of incipient aggregation is $1 : \pi$. This ratio is found to prevail in a comparison of the vector-radii of the aphelion planets in each of the aphelion or supra-asteroidal two-planet belts, with the vector-radii of the perihelion planets in each of the perihelion or infra-asteroidal belts, as is shown in the following table. The tabular unit is Sun's radius:

	A		B	(A-B) ÷ B
$♄ \times \pi^1$	6438.75	♆ *mean*	6453.06	—.0022
$♄ \times \pi^0$	2049.51	♄ "	2049.51	
$♄ \times \pi^{-1}$	652.38	✱ "	652.38	
$♄ \times \pi^{-2}$	207.66	⊕ *perihelion*	207.58	+.0004
$♄ \times \pi^{-3}$	66.10	☿ "	68.48	—.0361
$⊕ \times \pi^{-1}$	68.39	☿ "	68.48	—.0013

The close accordance between the deviation of $♄ \times \pi^{-3}$ and ⊕'s mean eccentricity, connects the supra-asteroidal with the infra-asteroidal planets, in a manner which is still further illustrated by the Neptunian, Jovian, and Telluric harmonic series of planetary positions*.

In the harmonic series of differences between perihelion nucleal pendulums $(\frac{56}{25})$, $(\frac{56}{24})$, $(\frac{56}{23})$, $(\frac{56}{22})$, $(\frac{56}{21})$† the inter-telluric terms were $\frac{1}{2}$ Venus

* *Ante*, xiii, 239. † *Ante*, xiv, 628.

and $\frac{1}{2}$ Mercury. If we take seven geometrical means between $\frac{1}{2}$ Mercury's, and Neptune's, mean radius-vector, we find the following accordances:

	Theoretical (T).	Observed (O).	(T-O) ÷ O.
$\frac{1}{2}$ ☿$_2$	.19355	.19355	
$\frac{1}{2}$ ♀$_2$	.36362	.36167	+.0054
$\frac{2}{3}$ ⊕$_3$	.68312	.68925	—.0090
$\frac{3}{4}$ ♂$_2$	1.28337	1.23312	+.0407
$\frac{4}{5}$ ✳	2.41103		
$\frac{5}{6}$ ♃$_3$	4.52954	4.52279	+.0015
$\frac{6}{7}$ ♄$_3$	8.50918	8.57149	—.0073
$\frac{7}{8}$ ♅$_1$	15.98670	16.03259	—.0029
$\frac{8}{9}$ ♆$_2$	30.0334	30.0334	

The geometric ratio of the theoretical column is 1.879, or almost precisely the sum of the co-efficients of the Urano-Neptunian belt ($\frac{7}{8} + \frac{8}{9}$). It will be observed that the theoretical co-efficients ($\frac{1}{2}$ ♀, $\frac{2}{3}$ ⊕ . . . $\frac{7}{8}$ ♅) are the same as appear in the inter-planetary abscissas of my Centauru-Heliacal parabola.* The collisions of particles, in their approach to the focus of a paraboloid, would naturally convert parabolic into elliptical orbits; and particles falling towards a cosmic focus from a distance nr would acquire the dissociative velocity (relatively to the Sun) $\sqrt{2gr}$, at $\frac{nr}{n+1}$ from the focus. By giving to n, successive values in arithmetical progression, we form the arithmetico-harmonic series, $\frac{1}{2}$ $\frac{2}{3}$ $\frac{3}{4}$ $\frac{4}{5}$ $\frac{5}{6}$ $\frac{6}{7}$ $\frac{7}{8}$, which constitute the peculiar sequence of co-efficients, both in the foregoing geometric series and in the abscissas of the primitive parabola.

The bases of the principal planetary harmonies that have been hitherto published, are:—Peirce (phyllotactic), the time of orbital revolution, t; Bode, and Alexander, the orbital radius vector, or the radius of possible solar-nebular atmosphere, r; my own (harmonic), the nucleal radius, ρ. Their common relations may be thus shown:—

Peirce, $t \propto t^{1} \propto r^{\frac{3}{2}} \propto \rho^{2}$

Bode, Alexander, $r \propto t^{\frac{2}{3}} \propto r^{1} \propto \rho^{\frac{4}{3}}$

Chase, $\rho \propto t^{\frac{1}{2}} \propto r^{\frac{3}{4}} \propto \rho^{1}$

The Saturnian relations of inertia seem to have established the Bode series. For if we take as our unit, $\rho_0 = 20.58$ solar radii, (ρ_0 being the nucleus of a nebulous sun which would rotate synchronously with Saturn's orbital revolution), we obtain the following values:—

	Bode (T).		Actual (O).	(T-O) ÷ O.
$1 = \rho_0$	20.58	♄ ⊙ *nucleus*	20.58	
4	82.31	☿$_2$	83.36	—.013
7	144.04	♀$_1$	149.93	—.041
10	205.78	⊕$_1$	207.58	—.009
16	329.23	♂$_2$	329.74	—.002

* *Ante*, xii, 523-1.

	Bode (T).		Actual (O).	(T-O) ÷ O.
28	726.16	Asteroidal		
52	1070.06	♃₁	1069.62	+.000
100	2057.78	♄₂	2049.51	+.004
196	4033.25	♅₂	4121.76	—.022
[292	6008.71]	♆₁	6388.25	—.063
388				

It will be observed that I have interpolated the Neptunian term, but this modification of the Bodeian law, as I have, in part, previously stated, increases its harmony, by giving three equal differences at each extremity of the series, by placing Earth's perihelion in a geometrical mean position between the ♄ ☉ nucleus and its limit of possible atmosphere, and by marking centres of linear oscillation of successive pendulums.

After the hypothetical detachment of the several two-planet belts, and their independent revolution preparatory to cosmical division, the harmonic should replace the geometric ratios. In order to remove the influence of the theoretical planetary pendulum unit ($\frac{1}{8}\odot r$) and the slight uncertainty as to the precise period of solar rotation, let us examine the *ratios* of the several planetary rotation- (or nucleal-) radii, and the consequent harmonic differences, according to the above equation of variability, $\rho \propto t^{\frac{1}{2}}$.

	t	ρ			
☿	.2408	.491	☿ ÷ ♀ = 5 ÷ 7.99	♃ ÷ ♄ = 5 ÷ 7.88	
♀	.6152	.784	⊕ ÷ ♂ = 5 ÷ 6.86	♅ ÷ ♆ = 5 ÷ 7.	
⊕	1.0000	1.000			
♂	1.8808	1.374	♅ — ♃ = 5.722	$\frac{12.837}{5.722} = \frac{56}{24.96}$	
♃	11.8618	3.444	♃ — ⊕ = 2.444	$\frac{5.722}{2.444} = \frac{56}{23.92}$	
♄	29.4565	5.427	⊕ — ☉ = 1.000	$\frac{2.444}{1.000} = \frac{56}{22.91}$	
♅	84.0190	9.116	☉ — ½ ♀ = .392	$\frac{1.000}{.392} = \frac{56}{21.95}$	
♆	164.7791	12.837	½ ♀ — ½ ☿ = .147	$\frac{.392}{.147} = \frac{53}{21}$	

By comparing the radii of æthereal nebulosity; of synchronous central and circular oscillation ($2r : r$); of incipient aggregation, or constant pressure ($1.4232r$); and of nebular rupture $\left(\frac{nr}{n+1}\right)$, we find the following accordances:

1. An æthereal atmosphere, rotating with planetary velocity at Sun's present surface, would have the equatorial velocity of light at $688.33r$.

3 × 688.33	2064.99	♄₂	2049.51
6 × "	4129.98	♅₂	4121.86
9 × "	6194.97	♆₁	6388.25

2. If the radial oscillation and the radius of nebular rupture are specially regarded, $r = \frac{1}{2}$ radius vector; $n = 2$; $\frac{nr}{n+1} = \frac{2r}{3} = \frac{1}{3}$ radius vector.

$\frac{1}{3}$ ♃	1.6594 ♂$_3$	1.6444
$\frac{1}{3}$ ♆$_2$	10.0113 ♄$_3$	10.0000
$\frac{1}{3}$ ⊕$_2$	.3333 ☿$_1$	.3187

3. Substituting the orbital radius for the radius of linear oscillation, we have $\frac{nr}{n+1} = \frac{2}{3}$.

$\frac{2}{3}$ ♆	20.0226 ♁$_3$	20.0442
$\frac{2}{3}$ ⊕$_3$	.6763 ♀$_1$	.6978

4. Substituting the radius of incipient aggregation and its corresponding radius of linear oscillation, we have

$$\frac{nr}{n+1} = \frac{1.4232\,r}{2}; \quad \therefore\ n = 2.467$$

$2\,n$	4.934 ♃$_1$	4.978

The combined influences of Jupiter and Earth over the asteroidal belt, especially as shown in the second and fourth accordances; the tendency of their mean radial velocities (at 1.4232 r) and the limiting satellite velocities, to equality at Sun's present limiting planetary velocity; the indications of uniform primitive velocity, furnished by the general predominance of geometrical ratios and the introduction of harmonic values in the minute details; the *a priori* probability of such primitive uniformity; the relations of mass and position to orbital times, as well as to atmospheric and nuclear-nebular radii (t, r, and ρ); all point to originating undulations, propagated, as inferred from the ultimate limit of equality towards which the parabolic cometary and mean radial centrifugal velocities both tend, with the velocity of light.

La Place (*Mécanique Celeste*, II, viii, 65–69; VI, ii, 12–16; etc.) investigated a number of inequalities depending on the squares and products of the disturbing forces. In his discussions of the Jovian and Saturnian systems he introduced terms containing the 3d and 5th dimensions of the eccentricities and inclinations. The closeness of the agreements here presented may, perhaps, lead to important considerations involving still higher powers.

If we substitute for the theoretical primitive exponential ratios (1, 1+2, 1+2+3), the present actual vector radii, ($\alpha =$ ♆$_2$; $\beta =$ ♁$_2$; $\gamma =$ ♄$_2$; $\delta =$ ♃$_2$), we find an equation for Saturn's mean perihelion :—

$$\text{♆}_2^{\delta} \times \text{♁}_2^{\beta-\delta} \times \text{♃}_2^{\alpha} = \text{♄}_1^{\alpha+\beta} \qquad (1)$$

If α, β, δ, represent the mean aphelion vector-radii, we find an equation for Saturn's mean distance :—

$$\text{♆}_3^{\delta} \times \text{♁}_3^{\beta-\delta} \times \text{♃}_3^{\alpha} = \text{♄}_2^{\alpha+\beta} \qquad (2)$$

If we take powers of the masses, instead of powers of the vector-radii, equation (2) gives two values for Saturn's mass, according as we use Newcomb's greatest value of Neptune's mass, ($\frac{1}{19380}$), deduced from its satellite (3)

or the least, ($\frac{1}{19700}$), deduced from perturbations of ♁ (4)

These equations are immediately suggestive of the numerous familiar equations between the *sums* of periodic times. The substitution of *products* for sums, and powers for products, indicates the early organizing activity of constant forces, acting with reference to given centres, in elastic media.

The solution of equations (1) to (4) is as follows :—

(1)

Log. $30.03386^{5.202798}$	7.687712
" $19.183581^{19.183581-5.202798}$	17.936362
" $5.202798^{30.03386}$	21.511361
	47.135435
" $9.077645^{30.03386+19.183581}$	47.148979

$$.013544 \div 49.217441 = .000275 = \log.\ 1.00051$$

(2)

Log. $30.33551^{5.427351}$	8.043068
" $20.044183^{20.044183-5.427351}$	19.030955
" $5.427351^{30.33551}$	22.284102
	49.358125
" $9.538852^{30.3351+20.044183}$	49.346714

$$.011411 \div 50.379693 = .000227 = \log.\ 1.00050$$

(3), (4)

If log. ☉ = 10, the logs. of the assumed masses are :—

♆ (Newcomb, from satellite)	5.712646
♆ (" " perturbations)	5.705534
♃ (")	5.645892
♄ (Bessel)	6.455734
♃ (")	6.979689

Substituting these logs. for the aphelion logs. in equation (2), we get for log. ♄, by using for log. ♆

Satellite value	(3)	6.458198
Perturbation value	(4)	6.456439

$$6.458198 - 6.455734 = .002464 = \log.\ 1.0057$$

$$6.456439 - 6.455734 = .000705 = \log.\ 1.0016$$

Stated Meeting, December 3d, 1875.

Present, 14 members.

Vice-President, Mr. FRALEY, in the Chair.

Visitors. Mr. Schwartz of the Detroit Scientific Association, and Mr. Morgan Hart.

A letter acknowledging the receipt of Proceedings No. 94, was received from the Victoria Institute, dated London, Nov. 8th, 1875.

A communication respecting a so-called Calendarium perpetuum mobile, to be exhibited in 1876 by M. Kesselmeyer, was received from Mr. C. H. Meyer, Consul for the German Empire at Philadelphia.

Donations for the Library were received from the Netherland Botanical Society; Cobden Club; Glasgow Philosophical Society; Silliman's Journal; Academy of Natural Sciences; Penn Monthly; Journal of Pharmacy; Mr. Nystrom; and Prof. Kerr of North Carolina.

Mr. Britton exhibited and explained certain improvements in his laboratory burettes.

Mr. Lesley described the occurrence of certain Carboniferous valleys of erosion, discovered by Prof. Stevenson and Mr. White during the field-work season just closed, in Washington and Greene counties, Pennsylvania, on the horizon of the great sand-rock of the Lower Barren Measures, below the Pittsburg coal.

Mr. Price communicated a memorandum of the places around Philadelphia recently visited by him, where boulders may be seen. This list of points in the present limits of the city may be of historical interest at a future day.

I have lately visited the following excavations through gravel outside the built area of the city. In all are found pebbles and stones rounded by the action of water, and stones of all sizes up to some hundred pounds, unrounded, angular, and but slightly rubbed. Where the gravel is purest and deepest, and undisturbed, stratification is seen, and at a depth of eight or ten feet a black band of cemented gravel divides the gravel from the fine sand below:

South side South Street east of new bridge; south side Woodland Ave-

nue, both east and west of Woodlands Cemetery; 46th Street, both south and north of Woodland Avenue; 45th Street, south and north of Kingsessing Avenue, and north of Spruce Street; Chestnut Street, west of 45th and 47th Streets; intersection of Pennsylvania and Connecting Railroads; Girard Avenue, west of 48th Street; Elm, west of Girard Avenue; Girard Avenue east of the bridge, in the Park; in the Park east of Connecting Railroad bridge over the Reading Railroad; Jefferson and 28th Streets; Cumberland Street and 15th; and 12th and Cumberland Streets; also east of Reading Railroad bridge over the Schuylkill, and around the basin in the East Park.

The "erratics" are found at all heights, twenty to one hundred feet above tide, both sides of the Schuylkill.

Prof. Chase described some indications of Saturn's importance in influencing the early planetary aggregations of our system when the Sun was in a nebulous condition. He introduced an equation between the masses and distances of the four outer planets, which accorded with other present indications of nebular activity in Saturn.

The Treasurer's annual report was, on motion, postponed, on account of his serious illness.

Pending nomination No. 791 was read.

Mr. Price presented the following report on the application of the funds of the Michaux Legacy:

December 3, 1875.

To the American Philosophical Society:

I respectfully make report in relation to the expenditure of the income of the Michaux Fund placed at the disposal of the Fairmount Park Commission.

The Botanical Committee of the Society, Aubrey H. Smith, Chairman, revised the list of trees proposed to be imported last spring; and nine hundred and ten trees were imported from James Booth & Sons, Hamburg, Germany, and arrived and were planted early in May last. They were fine, healthy, well-grown trees, and were generally in good order when received. There were one hundred and forty-five species and varieties of Maple, Horse-Chestnut, Ailantus, Alder, Birch, Hornbeam, Spanish-Chestnut, Catalpa, Beech, Laburnum, Ash, Larch, Poplar, Prunus, Pterocarya, Pyrus, Oak, Lorbus, Linden, Willow.

There are now growing of this and the previous importation by the same Michaux Fund, one thousand one hundred and seventeen trees and shrubs, of two hundred and sixty-seven species and varieties. These are all in the nursery, where they will remain until of a size to be planted out in the "Michaux Grove" and elsewhere over the Park.

I have collected from the Woodlands Cemetery, formerly the seat of William Hamilton, and from the Marshall Garden, and with the aid of Dr. George Smith of Delaware County, and Aubrey H. Smith, Esq., from other places, considerable quantities of acorns and seeds without cost, and had them planted in the Nursery of the Park, in furtherance of Mr. Michaux's purpose, to wit: of the European Oak, the English White Oak, Red, Scarlet, White, Black, Post, Willow, Swamp, Chestnut, Rock and Overcup White Oaks; and the seeds of the Sweet Gum. The Bartram acorns came from Humphrey Marshall of Marshallton, Chester county; and a lot of them, separately planted, were procured by Dr. Leidy from a forest tree, near Columbus, N. J. Mr. A. H. Smith, in sending these says, "If these, or any of them, germinate we shall have an authentic specimen of the Bartram oak at last."

In addition to the duty of making the Society acquainted with the manner in which its funds have been used, I have in view the purpose to invite through your publication, the contribution to the Fairmount Park Nursery, of acorns and seeds of all rare forest trees that will stand our climate, by friends of the Park, and lovers of trees and science wheresoever they may be, with the expectation that the Park will in the future become a point of distribution of rare trees to other Parks and of their fruits.

The Park Commission stipulated with this Society, March 12, 1870, that after planting the Michaux Grove, any surplus of the income of the Michaux Fund "shall be devoted to the cultivation of Oaks of every variety capable of cultivation in our climate, in the Park Nursery, which Oaks, to the extent of two of each kind cultivated, (shall) be hereafter distributed to other Public Parks in the United States." Of acorns and seeds the only limitation would be in the production of the trees.

ELI K. PRICE,

Chairman of the Committee of Fairmount Park upon Trees and Nurseries, and Chairman of the Committee of the Society on the Michaux Fund.

On motion of Mr. Price, it was

Resolved, That Thos. O'Donnell and Albert S. Allshause be respectfully invited to furnish this Society, at each of its meetings, a report of their borings on the south side of Elm Avenue, near the Centennial buildings, and to furnish the museum of the Society with specimens of the rocks bored through.

On motion of Mr. Price, it was

Resolved, That a committee of five be appointed to make arrangements for the delivery of the address of the Hon. Wm. Strong on the life and character of the Hon. Horace Binney.

Mr. Price, Mr. Fraley, Mr. H. J. Williams, Mr. Hopper and Judge Sharswood were appointed the committee.

On motion of Mr. Lesley, the Secretaries were authorized to complete the set of the Society's Proceedings and Transactions in the Library of the University of Pennsylvania, receiving in return such duplicates as are in that Library.

The Secretaries were instructed to prepare a reply to the communication of Herr C. Kesselmeyer, transmitted to this Society by Mr. Chas. H. Meyer, German Consul, and member of the Centennial Commission of the German Empire (224 S. Fourth street, Philadelphia), stating that the regulations of the Society will not admit of a compliance with his request.

And the meeting was adjourned.

Stated Meeting, December 17th, 1875.

Present, 10 members.

Vice-President, Mr. FRALEY, in the Chair.

Donations for the library were received from M. Donisotte of Turin; the Royal Prussian and Belgian Academies; Revue Politique; London Nature; Boston Natural History Society; Cambridge Museum; Franklin Institute; Medical News, and the U. S. Department of the Interior.

The committee on the paper of Drs. Le Conte and Horn, entitled "On the Rhyncophora of North America," reported in favor of its publication as a separate Volume (XV, No. 96, of the Proceedings). On motion, it was so ordered, with an appropriation of fifty dollars for illustrations; the Secretary being authorized to commence the minutes of 1876 as No. 97, Vol. XVI.

The Committee to which was referred the Memoir on the Rhyncophora of N. America by Drs. LeConte and Horn, report that they have examined the MSS. and find the following facts.

The memoir consists of about five hundred MSS., equal to about four hundred printed pages, and require a few simple wood cuts in the text, costing about twenty-five dollars, and one lithograph plate costing about twenty-five dollars. Dr. Horn proposes to draw on the wood himself.

The subject is of great scientific interest, being a new classification of eleven families of Coleopterous insects in three series, upon the basis of a wider and closer study of all their features than has yet been made; and after personal inspection of the cabinets of Europe. The families of insects described belong to the class of weevils in the language of agriculture.

We recommend that the memoir be printed separately as No. 95 and Vol. XV of the Proceedings, with the necessary appropriation of fifty dollars for illustrations; and that the Secretaries be authorized to commence the publication of the Proceedings of 1876 with No. 96, page 1, Vol. XVI.

Dr. Brinton communicated the results of his correspondence with Dr. Valentini, of Mexico, and read a statement of Dr. Valentini's theory of the Calendar Stone, as a votive tablet to the Sun God, deducing important historical data therefrom. Dr. Brinton reported that the MSS. had been sent to him, and moved the appointment of a committee to report whether it deserved publication. Dr. Brinton, Prof. Kendall and Mr. Lesley were appointed the committee.

The author, in the introductory part of his memoir refutes the theory prevalent on the meaning of the Mexican Calendar Stone. This theory was advanced by Don Leon y Gama, in the year 1490, and may be condensed into the following:

The stone is a sun dial, and has the additional function of showing:

1. The two transits of the sun by the zenith of the City of Mexico.
2. The two equinoctial days.
3. The day of the Summer Solstice.

The way of ascertaining these days has been to set above the stone an apparatus, constructed of eight vertical poles, whose points were connected by threads; and the shadows of these threads, on the above-said days, would fall upon the surface of the dial, and cut the figure of the respective hieroglyphics and thus determine the day of the celestial phenomenon.

The day of the Winter Solstice is supposed to be sculptured upon another stone of the same kind, which is still to be discovered.

The author shows that the stone lacks all the requirements necessary for representing a sun dial; he doubts, whether the Mexicans had been acquainted with the existence of the named astronomical days; he further proves that the two hieroglyphics, or the pretended equinoctial, and the two for the pretended Transit days, simply refer to the four tablets that represent the four destructions of the world, and that they designate the days on which the Mexicans were accustomed to celebrate a feast in order to commemorate those pre-historic events; and, finally, that the day for the pretended Summer Solstice turns out to be the hieroglyphic for the

five Mexican supplementary days, called the nemotemi (5 + 360 days). Hence, the premises of this theory being incorrect, the conclusion must be incorrect also.

The theory of the author is the following:

The Mexican Calendar Stone is a votive monument dedicated to the Sun God in the year XIII Acetl. As in the series of the fifty-two years, which form a Mexican cycle, the year of the name XIII Acetl was the last one, the people looked at it with fright. For they believed that the Sun God, at the lapse of each cycle would destroy the world, and, therefore, the happy entrance of a new cycle was considered by the people to be a special indication of his mercy. The motives of the dedication thus explained, the author transcribes the year XIII Acetl, which is sculptured in a tablet at the top of the stone, into that of 1479 of our era, and gives the reasons for doing so. He then proceeds to ascertain the person to whom the stone was dedicated, and from the central position of an image, from its ornaments, and from a hieroglyphic sculptured on its frontlet, he comes to the conclusion that this image is that of the sun god, *Atoniatuh.*

These preliminary questions settled, the author passes to the minute description and final definition of all those hieroglyphics which in successive and concentric zones surround the image of Atoniatuh. He says, as the intention was to glorify the Sun God, the great giver of time, the artist chose to sculpture in the spaces of the concentric zones all those symbols by which the Mexicans used to represent time and its division. In the immediate vicinity of the image the artist placed *the zone of the Aeons*, in the form of four tablets upon which the four destructions of the world, the most ancient deeds of the Sun God, are found to be sculptured. Next comes *the zone of the twenty days*, which constitute a Mexican month. Each of these twenty days has its special image. Then comes *the zone of the two hundred and sixty Lunar days*, divided into weeks, each of these being subdivided into five days; and around this zone lies *that of the one hundred Solar days;* for, according to their peculiar way of computing time the circle of the ancient Mexican year was split into those portions. *The five days wanting* to make their year a more correct one will be seen to be intercalated within the space between the tablets of the two last destructions of the world. *The sixteen hours* of the Mexican day are represented by gnomons, which at proportionate distances intersect the zones. The last zone, girdling the whole monument is occupied by the symbols for the cycle. Thus, every kind of symbols representing division of time will be found to be sculptured on the monument and brought into symmetrical relation to the image of him whom they considered to be the primeval origin of all time.

Special attention has been paid by the author to the *Zone of the Cycles*, which he calls the *Chronological Zone.* It is divided into twenty-four tablets. Each of these is like the other and contains the picture which was employed for designating the lapse of a cycle of fifty-two years. It

shows a shaft, vertically placed upon a disk, rom which four flashes of smoke and fire curl up. By this picture was expressed the solemn act of re-kindling the sacred fire ; a ceremony which took place before the assembly of the whole people in the last hour of the cyclical year. The identity of this picture, sculptured, with that painted in the Mexican Codies is exemplified by copies taken from the large collection of Lord Kingsborough, and its correct interpretation is warranted by referring to the authentic text. The author now says : That, if the stone evidently was consecrated in the year 1479 : if further, the tablet containing the sign for this year not only is fixed at the top of the monument, but also, within this cycle-zone and at its top : and finally, if two large pointers are seen to lead the two halves of this zone toward this same tablet of 1479—the artist's intention has been to give to understand that the Mexicans, in the year 1479, had counted the sum of twenty-four cycles elapsed, or twenty-four festivals celebrated in honor of their Sun god. Twenty-four cycles represent the sum of one thousand two hundred and forty-eight years. This sum subtracted from the year 1479 leads back to a year of our era equivalent to 231 A.D. Hence, the stone not only shows division of time, generally, but also a definite quantity of time, which the benignant Deity had granted to his people. To find a chronological record of this kind sculptured upon this monument appears to be in full concordance with its votive character.

The author is of the opinion, that by the year 231 A.D. the date has been expressed from which the civilized races of Mexico and Yucatan began to reckon a new political or religious era. His computations of the chronologies written by Satlilxodritl, Veytia and Chimalpopoca, and of that of the Maya-people, have given him an almost identical result. The variations are : 231 A.D., 242 A.D., and 245 A.D.

Dates prior to these, and mentioned in Mexican history, can now be correctly determined. Thus, the year X Calli, that of an universal eclipse of the Sun, is equivalent to our year 137 A.D. = Lapse of the great Sothic period in the Orient, and coinciding with the Mexican date of the departure of the civilizing races from the distant *Tulapan*. The year 1 Tecpatl proves to be equivalent to 29 B. Cr. = Introduction of the Julian calendar in Asia Minor by Cæsar Octavianus, and it is called by the Mexicans : the meeting of the Astrologers in Huehuetlapallan for the purpose of correcting the calendar.

These latter suggestions do not enter into the memoir, but will be more extensively treated in a later paper, if that of the Mexican Calendar Stone should meet with a favorable reception.

Mr. Walter presented to the library of the Society, as a gift from Mr. John McArthur, Jr., architect of the New

Public Buildings of Philadelphia, several photographs of ornamental portions of the work, remarking that he considers the style of ornamentation inaugurated in these buildings, as surpassing in design and modeling, any esthetic embellishments in architecture ever before attempted in the United States. He called the attention of the members especially to a head of the late Hon. Horace Binney sculptured in high relief on the keystone of the arch-way leading to the Judiciary, remarking that it was modeled from a photograph of Mr. Binney taken about a year before his death, and furnished for the occasion, by his daughter, Mrs. Montgomery.

Allegorical faces in high relief, representing Remorse, Sympathy, Knowledge, Commerce and Liberty; also the head of a buffalo, the head of a lioness, and other devices adorn the various keystones, no two being alike, and each representing an apparent idea or association.

As the ornate portions of the buildings are modeled and photographed, the Society will be furnished with copies for the library.

Mr. Blazius read a paper On the influence of Air on Life, and the connection of the westward growth of cities with modern meteorology. A discussion ensued in which Mr. Price, Mr. Walter, Mr. Lesley, Mr. Fraley, Mr. Briggs and Dr. Horn took part.

Pending nomination 791 was read.

The stated business of the evening was postponed on account of the continuous illness of the Treasurer.

The Committee on Judge Strong's address reported that it should be delivered on the 5th of January next, at 8 o'clock P. M., in Musical Fund Hall.

And the meeting was adjourned.

SOME REMARKS ON THE CONNECTION OF METEOROLOGY WITH HEALTH.

By William Blasius.

(*Read before the American Philosophical Society, December 17th*, 1875.)

Sometime ago an architect asked me the question whether I could assign a philosophical reason for the well-known fact, that during all ages, cities, where topographical impediments do not interfere, extend as a general rule from east to west, and that the wealthiest people are always in the advance. As an instance of this kind, I will remind you of the West End in London, and of our fashionable Chestnut, Walnut, Spruce, and Pine Streets, which have grown steadily in this manner from the Delaware to the Schuylkill.

I had before paid some attention to this question under a somewhat different form, namely: What influence in reference to aerial currents has the position of a city or a dwelling house on the health of the inhabitants?

In speaking of a healthy or unhealthy location of a city or a house we hear frequently, in the reasoning on these points, the remarks made that it is on high or low ground, indicating thereby that a house is respectively healthy or unhealthy. This generally conceived impression has doubtless been derived from the idea that low ground must necessarily form a swamp, in which malarial gases are generated. Although this may be the case in many instances where no drainage exists and the ground is impervious to water, it is not always so; for the formation of a swamp depends more upon the geological formation than upon the altitude. I have seen swamps on mountains as well as on low ground, and houses close to a swamp on low ground perfectly healthy, while those standing on high ground and far off from a swamp were most unhealthy. The cause of malarial diseases must then be found in some other conditions, also.

Twenty or thirty years ago, when geology became more fully developed, medical men tried to find the cause of many diseases in the nature of the soil or in geological conditions, and I have no doubt that this has, indirectly, something to do with our health. A little later some diseases were traced directly to impure drinking-water. But it is only recently, that physicists began to suspect the air as the principal mischief maker. And if we consider that we eat only three times a day, drink water but twice as much, but drink or breathe air about fifteen times every minute, it becomes at least very probable that the air is the chief culprit that smuggles the poisonous matter into our system. For we inhale eighteen cubic feet of air every hour, or four hundred and thirty-two per day; and three-fourths of our weight has been built up of its material. This enormous consumption of air is performed almost unconsciously, at least without paying any attention to its quality, as we would naturally do in drinking-water. Because the air is invisible and tasteless the majority of people are scarcely aware of its existence, much less of its impurities

in certain localities, particularly in large cities. The most wonderful discoveries have been made in this direction by Ehrenberg, Schroeder, Pasteur, Dr. Smith, Schwann, Cohn, Dr. Bastian, Tyndall, Pettenkofer, and others.

Schroeder succeeded first in filtrating air by letting it pass through chemically pure cotton into a glass cylinder, from which the air had been exhausted by an air-pump.

The eminent French chemist, Pasteur, by using chemically pure gun cotton, which he, after the filtration, dissolved in ether, succeeded in collecting all impurities of the filtrated air, and subjecting the fluid to a microscopic investigation, he observed myriads of fungi and still smaller living organisms as Bacteria and Vibriones in it. He says: "It appears that our knowledge of contagious diseases, especially at periods when epidemics rage, would be increased by work carried out in this direction." Following his own suggestions, he was enabled to prescribe a means of preventing the disease known as "pébrine," which made such havoc amongst the silkworms in France.

Schwann showed that a fluid which produced myriads of such lower living organisms if left in contact with ordinary air, would keep free of them if first boiled and then brought in contact with air previously heated to redness; proving thus clearly that the germs of life came from the air. It also was proved that meat, fruit, etc., will preserve in pure air from one to two years and that fermentation and decomposition is carried on by the assistance of such minute organisms in the air. The conclusions, then, are not so far off from the truth that such minute parasites if in sufficient numbers, may, in entering on the wings of the air into our system, attack delicate or diseased organs, producing fevers, such as diphtheria, scarlet fever, etc. In the fall and spring, the times of sudden weather changes, we see an ordinary cold or catarrh in children change frequently into diphtheria, or other similar diseases.

Blackley considers he has proved that hay fever is caused by the inhalation of air containing pollen in considerable quantity, which adheres to the membranous lining of the larynx and air-passage and causes secretion from these parts. A solution of quinine, which is destructive to minute forms of life, has been shown by Helmholtz to be an effective application in cases of this disagreeable malady.

Tyndall, in 1870, gave us a means of investigation supplementary to the microscope, and of extreme delicacy. He proved that particles, which in a liquid are quite invisible under an object glass readily showing bodies of $\frac{1}{100,000}$ of an inch in diameter, were revealed with greatest ease by means of a beam of light. If the air were pure, a beam of sunlight traversing a darkened room would be invisible except where it struck upon the wall. The scattering of the light by floating dust and living organisms makes the track luminous to the naked eye. We may, to a certain extent, see these impurities dancing in a beam of light which enters through the shutters into a darkened room.

Dr. Smith made an experiment with a bottle holding five litres, which was refilled five hundred times with Manchester air. Dancer in examining this quality of air with magnifying powers from 120 to 1,600 diameters of an inch found the following bodies:

1. Particles of vegetable tissue, many of them partially burnt and quite brown in color.
2. Fragments of vegetation resembling in structure hay, straw and hay seeds.
3. Hairs of plants and fibres resembling flax.
4. Cotton fibres both white and colored.
5. Starch granules.
6. Wool white and colored.
7. In greatest abundance fungoid matter, spores and sporidia varying in size from $\frac{1}{10,000}$ to $\frac{1}{30,000}$ of an inch in diameter.

Many of the spores were living and developed forms resembling rust and mildew. A calculation was made as to their number in the following manner:

Under each field of the microscope there were more than one hundred spores. In each drop of liquid there were over 250,000; the whole quantity consisting of one hundred and fifty drops there were in this water no fewer than 37½ millions of spores visible. This quantity of air is the amount respired by an average sized man actively employed during ten hours in Manchester.

There is then hope that science soon will trace the source of many if not all of those mysterious deadly diseases and epidemics, and in finding their source, the remedy and preventive will be furnished at the same time. So much, however, is now already known that those destructive minute organisms in company with the well-known poisonous and noxious gases, originate principally in localities where vegetable and animal matter are decomposing; in thickly populated cities, on and underneath the pavement, gutters, yards,—in swamps and rivers into which sewers throw their contents. Here the air must become, so to say, saturated with these deadly poisons. We, therefore, understand that thoughtful people abhor such places, and flee away from them. But as the air loaded with these deadly poisons, does not stay where it generates, nor flow promiscuously in all directions, it becomes of some importance to know where we have to go, so as not to meet it; and here comes the youngest of the physical sciences, Meteorology to our assistance. In a lecture which I had the honor of delivering before you some two years ago, I showed that air in its motion follows strict laws the same as water, and that the direction and nature of its currents are dependent upon the season, the configuration and nature of the surface of the earth. According to these laws we experience in our latitude during Summer a prevailing current from the southern semi-circle principally from the southwest, south or west; in the Winter a prevailing current from the northern semi-circle, principally from northwest and north. Air of the same temperature or currents flowing in

the same direction do not mix much. Thus an offensive air-current coming from the opening of a large culvert would be perceived over a distance of 5 to 6 blocks, but only in space corresponding in width and depth to the opening from whence it issues. As the development of organized life, as well as of other noxious elements, in the air takes place principally during the warm season, when the prevailing wind in our latitude comes from the southwest, it follows that a house or a city to the north, northeast, or east of a source of such disease-brewing miasmas cannot be healthy, whether they lie high or low, or even if they are far off from this source; but if they are situated to the south, southwest or west, of such a hot-bed of miasma, they will not suffer from such localities, even if it is close by and on low ground. As the miasma carrying southern current is warm and rises over the highest mountains, it certainly will reach a house or a city lying 10 or 100 feet higher than a swamp. I know houses close to a swamp or river, those southwest of them are perfectly healthy, while those much further off, higher and to the northeast of them are uninhabitable on account of malarial fever. Illustrations of this apparent anomaly are frequent. Along low swampy rivers in summer you will find the eastern shore unhealthy, while the western shore is healthy. To bring matters home to us, I would say that West Philadelphia generally, even the Almshouse and Pennsylvania University, so close to the swamps of the Schuylkill, enjoy, during the dangerous warm season, the purified air from agricultural Delaware county, while the fashionable residences along the eastern shore of the Schuylkill are most exposed to the miasmatic air from the Schuylkill, into which the sewers throw their contents, from the swamps along its western shore, and from the lower portion of the city. Camden, situated to the east of two such rivers, with their swamps, and an artificial swamp between them, this city has still more to suffer. A friend wishing to buy a house upon the western slope of Brooklyn Heights was advised by physicians to choose rather the eastern side; since upon the western slope, even at the summit, malarial fevers are more numerous and more virulent. The reason for this is obviously that the wind which brings the miasma from the river and the low lands to the west and southwest is a warm one, and thus reaches the highest point west of Brooklyn Heights, but *passes high above* the lower land to the east. As little as any of us would like to drink the water of a river in which decomposition from vegetable and animal matter is going on, so little would we like to drink out of an air current saturated much more with poisonous gases and destructive organisms, if our eyes and tongue were sensible of it. This is the reason why a house in the western portion of a city is more healthy than one in the eastern or northern portions, and why cities extend to the west, not to the north, except where impediments determine their direction; in this case those living most to the north will have to pay the penalty in the rate of death. This is also the reason why in a well regulated city no noxious factories should be allowed on its western or southern side, such as the limekiln above

Chestnut street, the gas works above Market street, cemeteries, etc. Any one who wants practical illustrations of the different effects of the same air current on the western and eastern side of the Schuylkill, may pay attention to his breathing before and after passing the Chestnut street bridge. It is also a reason why the streets of a city should run from southwest to northeast, and from northwest to southeast, in order that during the warm season the prevailing currents could ventilate them and change the poisonous air which generates in the streets and yards. It is probably the reason why in cities certain diseases become epidemic as it enlarges, which before are comparatively unknown.

How the direction and nature of prevailing air currents affect the health of cities can be seen by comparing the rate of death in two successive years, of which one brings quite a tropical, the other a more arctic climate, during summer. This would seem to be due fully as much to miasma as to the direct effects of the heat on the system.

The *Public Ledger* of July 14, 1874, had an article comparing the health of Philadelphia for the period June 15th to July 15th, of the years 1872, 1873 and 1874, in which the writer seems to ascribe the improvement manifested to better arrangements in city government. This of course would have its effect, but the difference seems to me unquestionably due in large part to the difference in the prevailing air-currents.

From the data the *Ledger* article furnishes, I have compiled the following comparison of mortality in the principal diseases, which is very striking in view of the fact that in June and July of 1872, the prevailing currents were from the southern semi-circle, and in the same time of 1874, from the northern semi-circle :

	1872. EQUATORIAL CURRENT.	1874. POLAR CURRENT.
Adults	135	51
Minors	1118	301
Cholera infantum	713	111
Marasmus	96	56
Debility in Infants	84	38
Convulsions	96	49
Cholera morbus	31	1

I have compared 1872 and 1874, because the contrast is strikingly marked ; the mortality during the same weeks of 1873 was about midway between, in conformity with the air-currents.

The whole subject is of the greatest interest and the utmost importance ; and the field of inquiry a very wide one, promising the most satisfactory results.

I have given these few suggestions merely to call attention to the subject.

Discussion.

Mr. Walter remarked that he considered the imperfect construction of ewers, cess-pools and traps connected with sinks and water-closets as the great source of many of our worst diseases. We have, it is true, a very general under-ground drainage throughout our city, but that is not all we need; our sewers and ducts may all be well enough, as far as they go, but unless it is rendered absolutely impossible for the foul air they contain being forced back, through imperfect traps, into our dwellings, we had better have no underground drainage at all.

Carelessly-jointed pipes, inferior fittings, badly-constructed traps, and unventilated soil pipes cannot fail to admit the sewer gas into our houses, which becomes a prolific source of disease and death. Pipes which drain bath-tubs and washstands are often introduced into soil pipes without trapping, and thus become conduits to convey the worst of sewer gases into our chambers; and even when such pipes *are* trapped the work is so unskillfully done as to render the traps liable to be siphoned out by descending water from above. He stated that he had a case of this kind to happen in a house of his own, where the plumbing was admirably done—it was an oversight, soon corrected, but there should be no oversights in the plumbing of a house. Nothing about house-building demands our consideration more seriously than the work of the plumber.

Another evil exists in the imperfect construction of sewers, and a want of skill in their design and location. Many sewers discharged into tide-water with their openings so much dépressed as to bring the top below high tide; this causes a flow when the tide is up, which forces the air back through traps and cess-pools with great power, and if sufficient vent is not found the sewer will rupture in its weakest spot. He remarked that he knew of a case of this kind, where the water and filth were forced several feet above the pavement—nothing will make a sewer so located safe, but an ample ventilating shaft, properly constructed.

Besides these sources of disease and discomfort there are others, many of which were alluded to in the interesting paper just read to the Society by Dr. Blazius. This subject may well engage the most careful study of the scientist.

Dr. Horn said:

While there are atmospheric influences affecting the health of the masses generally, in cities, which are at times troublesome or next to impossible to obviate, there are causes within the dwellings of our population no less potent, and which are entirely within our control.

It has been noticed by many not members of the medical profession that typhoid fever, scarlatina and diphtheria prevail with great frequency among the better classes of our population (especially typhoid fever); and to such an extent has this prevailed that scarcely a family is found in

which no one of the members has been affected, while in many several cases have occurred. This prevalence may be thought all the more remarkable when we consider the great external and internal cleanliness of the houses of our better classes of citizens.

There can be but little doubt that our house-drainage has contributed more to the detriment of the health of the above-mentioned citizens than those causes which are generally complained of. Owing to faulty construction of the drain-pipes, sewer gases find ready entrance into our houses and in certain directions of the wind and during a high tide these gases are driven backward from the mouths of the main sewers, and the offensive odors are perceived in the rooms in which are water-closets or stationary washstands. These gases force themselves through the usual traps because *there is no other means usually provided for their exit.*

Every house provided with a system of *under-drainage* should have a draft-pipe of *large* size leading from the drain upward, in a straight line above the roof of the house and open at the top so that a free draft may be allowed. Into this all water-closets or other waste-pipes should enter at a *right angle*, after a proper trap, and no waste-pipe should empty into any conductor unless the latter extend above the roof and be open at the top. Any attempt at obviating the evil, such as small draft-pipes from each water-closet to a chimney, etc., has been proven practically to be of no value.

The fault in the construction of the water-closets consists in placing that of the upper story, practically on the end of the main conducting pipe, and it is for this reason that it has been noticed that water-closets which are highest in the house are most offensive. Thus no external draft for gases is allowed for, and their entire volume must be discharged in the house, greatly to the detriment of the health of the inhabitants. The remedy suggested is easy of accomplishment, cheap, and effectual.

The ordinary methods of warming our houses by means of heaters of varying construction in the cellars, have without doubt some effect on those who breathe the air sent through the house *from the cellar.* Cellars are not usually the cleanest portions of dwellings, and are too often left to the care of servants, to become the respositories of rubbish, and at times filth, which accummulate, and the usual dampness of cellars together with the even temperature maintained are favorable to slow putrefactive processes, which yield germs by no means harmless. There can be but one remedy for this evil. All air to be distributed in a heated form should be drawn from the external atmosphere, and as hot air is distributed by means of pipes so also can pure air be obtained from the outside and taken directly to the hot chamber of the heater.

These remarks are necessarily short, but will, I hope, serve to call the attention of architects, and builders to at least two very serious defects in the "better class" of houses.

INDEX TO VOLUME XIV.

New Nominations Read.

	Page.
740 to 744	5
745 to 747	9
748, 7-9	12
750, 751	14
753 to 756	177
757, 758	180
759 to 763	183
764	185
765	299
766	420
767, 768	426
769 to 775	427
776	432
777, 778	432
779	433
780	434
781, 782	440
783	639
784 to 790	642
791	643

Members Elected.

* Members who have accepted by letter. † Members who have taken their seats.

*Agassiz, A	437
*Allison, J	437
Armstrong, G	180
*Blazius, W	645
Brown, J. C	18
†*Camac, W	18
*Campbell, J. L	639
*Carll, J. F	645
Chandler, C. F	437
Chapman, H	437
*Clarke, J. F	185
*Drown, T. W	639
*Frank, L. G	437
*Hagert, H. S	437
*Hall, C. E	645
*Himes, C. F	186
*Ingham, W. A	437
†Kenderdine, R. S	186
*Kirtland, J. P	422
*Kolbe, H	8
*König, G. A	186
*Langley, S. P	437
*Lapham, I. A	8
*Lockyer, J. N	18
Maxwell, G. C	645
*McArthur, J	437
*Moore, G. E	645
†Pearse, J. P	422
†Penington, E	437
*Platt, F	180
*Prime, F., Jr	437
Proctor, R. A	18
*Pumpelly, R	18
*Rawson, R. W	185
*Raymond, R. W	437
*Saditler, S. P	186
*Selwyn, A. R. C	186
*Sheppard, F	645
Sherwood, A	645
*Smith, St	645
Tatham, W. P	437
†Thayer, R., Jr	645
†Thompson, R. E	18
†Thomson, Fr	18
Viollet-le-Duc	437
*Von Hauer, Fr	185
*Wahl, W. H	8
†*Wilson, J. M	8
*Woodward, H	180
†Wootten, J. E	8
*Young, C. A	18

Member who has Declined.

Browne, J. C 176

Member Resigned.

Smith, L. P 421

Members Deceased.

	Page.		
Agassiz, Louis	6	Lyell, C.	428
Beaumont, Elie de	184	Naumann, C. F.	2
Binney, H.	639	Norris, G. W.	429
Brown, N. B.	433	Phillips, J.	175
Condie, D. F.	434	Proctor, Wm.	10
Emerson, G.	180	Quetelet, M. C.	13, 174
Goddard, K.	646	Read, J. M.	190
Gummere, S. J.	187	Shurtleff, Nat.	423
Harrison, Jos.	15	Sumner, Charles	13
Henderson, A. A.	435	Towne, J. H.	435
Kiernan, F.	423	Trego, C. B.	188
Lapham, I. A.	643	Whitman, W. E.	639
Logan, W. E.	638	Wyman, Jef.	183

Obituary Notices Read.

Price, E. K.; Obituary Notice of John Meredith Read 271-283
Roberts, S. W.; " " C. B. Trego 356-358
Sellers, Coleman; " " Joseph Harrison 347-356

Photographs of Members Received.

Alexander, St.	183	Peter, R.	423
Birch, Mr.	640	Rogers, F.	177
Green, T.	187	Sadtler, S. P.	432
Jarvis, E.	8	Sumner, C.	177
Meehan, T.	183	Thomson, R.	432

Stated Meetings.

January 2 1874, to April 17, 1874 1
May 1, 1874, to December 18, 1874 174
January 1, 1875, to May 21, 1875 418
June 18, 1875, to December 17, 1875 635

Annual Elections.

January 2, 1874; January 1, 1875 ..... 4, 420
Treasurer pro tem. elected 180
Librarian elected 7, 422

Correspondence.

Academy of Sciences, Chicago 435
Agassiz, Alex. 182
Beck, G. 15
Blasius, W. 174
Boston Athenæum 421
Channing, W. F. 175
Commissioners at Breslau, on J. R. Meyer's Doctrine of Heat 15
Congrès Internationale des Américanistes 421
Da Costa, Dr. 179
Department of the Interior, U. S. 435
Dexter's Bust of Agassiz 1
Everson, E. W. 15
Fairman, Mr. 174
Flagg, W. C. 187
Guizot, M. F. P. G. 186

Page.
Herschel, Cap. J. 1
Holden, W. 432
Holland Society of Sciences, Haarlem 190
Indian Sculpture 13
Kirtland, J. P. 184
K. K. Geol. Reich, Vienna 1, 421
Krauss, Fr. 183
Langley, S. P. 428
Leed's Philosophical and Literary Society 185
Leorgre, T. 178
Linnean Society of Normandy 427
Linnean Society of Lyons 421
London Horticultural Society 421
Naumann, Dr. Ernst 1
New Jersey Natural History Society 432
Noury, Roncière de 299
Ohio State Librarian 183
Patterson, R. 174, 646, 49, 50
Putnam & Sons (Amherst College) 419
Rantoul Literary Society 183
Renard, M. 646
Royal Prussian Academy 439
Royal Belgian Academy (Quetelet's Monument) 421
Royal Geographical Society, London 419
Silesian Society at Breslau 13
Society of Biblical Archæology at London 641
Société de Science Naturelle de Strasbourg 178
Summers, S. V. 15
Travers, G. 182
Trübner & Co. 439
Waldheim, Fischer de (Semicentennary) 637
Whittaker, W. 427
Williamson, R. S. 427

Business of the Society.

Building Fund Trustees' Report 425
Hall Telegraph ordered 432
Hall Repairs 426, 637
Hall Furniture 428
Hall Tenancy by the City 428
Michaux, Committee of Botanists 192, 299
Michaux Grove (E. K. Price) 183
Appropriation 192
J. O. Cresson 300
Interest 10, 176, 190, 439, 640, 648
Legacy Report 425
Peale Collection 646, 649, 650
Franklin's Portrait 192, 433
Photograph Album Ordered 433
Proceedings, Not to be sold 184
Edition to be 1250 649

New Correspondents Placed on the List.

Royal Asiatic Society of Japan 17
Society of Sciences at Cherbourg 5
Geological Magazine, London 428

Memoirs for the Transactions.

ALLEN, DR. *Page.*
Life Forms in Art..... 11, 15, 175, 177, 179

COPE, E. D.
Supplement to the Extinct Batrachia and Reptilia of North America..... 9

Written Communications in the Proceedings.

BARKER, G. F.
New Vertical Lantern Galvanometer, with Cuts..... 440, 445

BLASIUS, W.
On the connection of Meteorology and Health..... 667–671

BLODGET, L.
Downward Atmospheric Circulation as one Cause of Extreme Cold..... 150, 153

BRINTON, D. G.
Dr. Valentini's Theory of the Mexican Calendar Stone..... 663–665

BRITTON, B.
Analysis of Rocky Mountain Coals..... 350, 361

CHANNING, W F.
Meteorological Peculiarities of New England..... 154

CHASE, P. E.
Origin of the Attractive Force..... 111–113
Cosmical Thermodynamics..... 141–147
Saving Fund Life Insurance..... 148, 149
Cosmical Evolution..... 159–161
Jupiter-Cyclical Rainfall..... 193–195
Cyclial Rainfall at Barbadoes..... 195–216
On Gravitating Waves..... 344–346
Lunar Monthly Rainfall in the United States..... 416–418
On the Yearly Rainfall in the United States..... 613, 614
The Beginnings of Development..... 622–631
Further Relations of Magnetic Gravitating and Luminous Forces..... 607–612
Further Dynamic Co-ordinations..... 651–658

COPE, E. D.
Abstract of Remarks, January 16, 1874..... 110
On the Plagopterinæ and the Ichthyology of Utah..... 129–139
On the Zoology of a Temporary Pool on the Plains of Colorado..... 139, 140
Synopsis of the Vertebrata of the Miocene of New Jersey..... 361–364
On the Remains of Population on the Eocene Plateau of Northwest New Mexico..... 365, 482

CRESSON, C. M.
Results of an Examination of an Exploded Locomotive..... 264–271
Analysis of Rocky Mountain Coals..... 358–361
On the Effect of Magnetic and Galvanic Forces upon the Strength of Iron and Steel..... 603–606

DAVIDSON.
On the Transit of Venus at Nagasaki..... 423–426

DELMAR, ALEX.
On the Resources, Productions, and Social Condition of Egypt..... 232–255
On the Resources, &c., of Spain..... 301–344

FRAZER, P., JR. Page.
On the Color of the Moon..... 155
On the Exfoliation of Rocks near Gettysburg..... 295-297
On the Limonites of York County..... 364-370
On the Traps of York County..... 402-414
Description of Microscopic Sections of Trap, &c.. with plates..... 430-431

FULTON, J.
On the Somerset County Coal Beds in Pennsylvania..... 157-158

GABB, W. M.
On the Indian Tribes and Languages of Costa Rica..... 483-602

GENTH, F. A.
Investigation of Iron Ores and Limestones from Ore Banks on Spruce Creek, &c..... 84-99
Reply to Dr. T. Sterry Hunt..... 216
On American Tellurium and Bismuth Minerals..... 223-231

GROTE, A. R.
List of North American Platypterices, &c..... 256-264

HALL, C. E.
On Glacial Deposits at West Philadelphia..... 633-634

HOFFMAN, W. J.
On Cremation among the Pah-Ute Digger Indians..... 297-298, 414-416

HOUSTON, E. J.
On a Supposed Allotropic Modification of Phosphorus..... 108-110

KÖNIG, G. A.
On an Improvement of the Burette Valve, with cuts..... 218-223

LESLEY, J. P.
On the Geology of the Brown Hematite Ore Banks of Spruce Creek, Warrior's Mark Run, &c., with 44 woodcuts and a map..... 19-93

MARSH, B. V.
On the Latent Heat of Expansion in Connection with the Luminosity of Meteors..... 114-129

OUTERBRIDGE, A. E., JR.
On Electrical Spectra of Metals, with wood-cuts..... 161-173

PRICE, E. K.
Obituary Notice of Chief Justice Read..... 271-183

ROBERTS, S. W.
Obituary Notice of C B. Trego..... 356-358

SADTLER, S. P.
On a New Occurrence of Tartronic Acid; and on Glyceric Acid..... 615-619

SELLERS, C.
Obituary Notice of J. Harrison..... 347-355

STEVENSON, J. J.
On the Alleged Parallelism of Coal Beds..... 283-295
Notes on the Geology of West Virginia, with a map..... 370-402
On the Geological Relations of the Lignitic Groups of the Far-West..... 447-475

WILLIAMSON, R. S.
On Meteorological Observations taken on the Nile, in 1873; with tables... 632

Verbal Communications.

BARKER. *Page.*

On a New Lecture Galvanometer..... 438

BLASIUS.

On the Tornado of August 22, 1851..... 14

BLODGET.

On Sudden Variations of Temperature..... 175

On the Vertical Descent of the Atmosphere..... 439

BRIGGS.

On the Tornado of August 22, 1851..... 14

On an Explosion at the Hospital..... 419

On Some Principles of Meteorology..... 641

BRINTON.

On Dr. Valentini's Memoir..... 643

BRITTON.

On Rocky Mountain Coal Beds..... 187, 191

On Burettes..... 188

CARSON.

On the Franklin Portrait..... 433

CHASE.

On the Velocity of Light..... 9

On a New Plan of Life Insurance..... 16

On Myer's Theory of Heat..... 18

On Cosmical Evolution..... 177

On the Rainfall in the Years of Jupiter..... 179

On the Lunar Cyclical Rainfall..... 179

On the Magnitude of Gravitating Waves..... 420

On the Bunsen Gas Burner..... 429

On Gov. Rawson's Meteorological Observations..... 430

On the Signal Service Charts..... 640

On the Beginnings of Development..... 641

COPE.

On the Osteology of the Artiodactyls..... 7

On the Cretaceous Coal Beds..... 7

On the Extinct Batrachia of North America..... 10

On Orton's Expedition..... 11

On Colorado Fish..... 13

On the Zoology of a Temporary Pool..... 14

On Eobasileus Galeatus..... 17

On the Miocene Vertebrata of New Jersey..... 429

On Architectural Remains in New Mexico..... 636

CRESSON, C. M.

On Thompson's Colorimeter..... 10

On the Effects of a Lightning Stroke..... 10

On Analysis of Mammoth Coal..... 175

On a Locomotive Boiler Explosion..... 180

On Rocky Mountain Coals..... 191

On a New Bunsen Gas Apparatus..... 429

On Sections of the Ellengowan Coal..... 429

On Thermo-electric Currents..... 440

On the Action of Magnetism on Iron..... 636, 638

CRESSON, J. C.

On the Purchase of Michaux Oaks..... 300

DAVIDSON. *Page.*
On the Transit of Venus..... 423
DELMAR.
On Egyptian Statistics..... 184
On Spanish Statistics..... 422
DUBOIS.
On Assaying Metals at the Mint..... 177
EMERSON.
On the Peach Growing Belt..... 175
FRALEY.
On the City Tenancy of the Hall..... 428
FRAZER.
On the Color of the Moon..... 2, 176
On a Notation for Organic Compounds..... 18
On Certain Mineral Formulæ..... 180
On the Exfoliation of Granite..... 192
On a New Retort..... 419
On Tyndall's Critics..... 420
On Titanic Iron..... 430
On Microscopic Sections of Trap..... 430, 436
On York County Limonites..... 433
On the Glaciation of the South Mountains..... 647
FULTON.
On the Coal Beds of Somerset County..... 176
GABB.
On the Indians of Costa Rica..... 638
GENTH.
On Recent Analyses of Limonites..... 9, 84
Reply to Dr. T. S. Hunt..... 180
On American Tellurium Minerals..... 181, 636
GOODFELLOW.
On the Transit of Venus..... 191
GROTE.
On North American Lepidopteræ..... 189
HOFFMAN.
On Pah-Ute Cremation..... 191, 436
HALDEMAN.
On a Sumatran Coin..... 16
HALL.
On Glacial Action at the Gaps..... 620, 641
On Glacial Blocks at Philadelphia..... 647
HARDEN.
On Mining the Brown Hematites..... 99
On a Model of Coal Lands in West Virginia..... 177
HORN.
On the Death of Trees in the Park..... 10
On the Health of Houses..... 672
HOUSTON.
On a New Form of Phosphorous..... 7
On an Igneous Rock near Philadelphia..... 16
KÖNIG.
On an Improved Burette Valve..... 181, 191
On Perowskite in Arkansas..... 640

LE CONTE. *Page.*
On Cretaceous Coals in the West 7
On the Zoological Society's Grounds 10
On a Medallion of Agassiz 16
On Grote's North American Lepidopteræ 189
On Pah-Ute Cremation 436
On the Rhycophora of North America 649

LESLEY.
On the Warrior-Mark Map 2, 9
On Chance's Port Clinton Fault 183
On the Progress of the Geological Survey 185, 440
On Former Mountains at Philadelphia 436
On Ashburner's Coal Beds in No. X 638
On Hall's Glacial Blocks at Philadelphia 644
On Harger's Vernier 647

MARSH, B. V.
On the Luminosity of Meteors 12

ORR.
On Phosphorus Bronze 12

POOLE.
On the Gold Field of Nova Scotia 189

PRICE, E. K.
On the Michaux Grove 10, 183

PRICE, J. S.
On the Hall Repairs 428

SADTLER.
On Glyceric Acid 641

SMITH.
On Mrs. Davidson's Letter 423

STEVENSON.
On West Virginia Geology 425
On the Lignitic Coals of the West 636

STOKES.
On the Peach Growth 175

STUBBS.
On Indian Sculpture 13

WALTER.
On Causes of Disease in Houses 672

WHARTON,
On Artic Expeditions 422

WILLIAMSON.
On the Meteorology of the Nile 22

Subjects Discussed at the Meetings.

Agassiz Medallion 16, 17
Albert Medal of the S. of Arts 637
Amazon Expedition of Prof. Orton 648
Archæology of New Mexico, Cope 475
Atmospheric Circulation, Blodget 150
Attractive Force. Chase 111
Bald-friar Indian Sculptures 13
Bismuth. Genth 181
Boiler Explosion. Cresson 180

Page.
Boulders in West Philadelphia..... 647
Brontotherium Injens..... 2
Bunsen Gas Apparatus. Cresson..... 429
Burette Valve. König. Britton..... 181, 188, 191
Coal of Somerset. Fulton..... 157
Coal of Ellengowan. Cresson..... 175, 429
Coal of Rocky Mountains. Britton..... 187, 191, 358, 361
Coal of Rocky Mountains. Stevenson..... 447
Coal Beds Discovered in No. X. Ashburner..... 638
Coal of Big Sewell Mountain. Harden..... 177
Coal Beds of West Virginia. Stevenson..... 370–402
Cold, Cause of Unusual. Blodget..... 150
Color of the Moon. Frazer..... 2, 155
Colorado Prehistoric Remains. Cope..... 139
Corundum. Genth..... 180
Cosmical Evolution. Chase..... 159
Cosmical Thermodynamics. Chase..... 141
Costa Rica Ethnology. Gabb..... 483
Cremation among the Pah-Utes. Hoffman..... 191, 414
Development, Origin of. Chase..... 622
Egypt's Population, &c. Delmar..... 184
Electrical Spectra of Metals. Outenbridge..... 162
Elie de Beaumont's Statue..... 427
Ellengowan Coal Analyses. Cresson..... 429
Eobasileus Galeatus. Cope..... 17
Exfoliation of Granite. Frazer..... 192
Explosion at Kirkbride's Hospital. Briggs..... 419
Fault at Port Clinton. Chance..... 300
Formulæ for Mineral Species. Frazer..... 180
Fossil Ore at Tyrone. Lesley..... 102
Galvanometer for Lectures. Barker..... 438
Geology of Spruce Creek. Lesley..... 19, 83
Geological Survey of Pennsylvania..... 185
Geology of Lake Erie Shore. Lesley..... 440
Geology of West Virginia. Stevenson..... 370, 402
Glacial Drift beneath the Virginia Shore..... 18
Glacial Action at the Water Gaps. Hall..... 620
Glacial Moraine at Philadelphia..... 633, 644
Glaciation in the South Mountains..... 647
Glyceric Acid. Sadtler..... 615
Gneiss Mountains Formerly at Philadelphia..... 436
Gold in Nova Scotia. Poole..... 189
Granite Exfoliation. Frazer..... 192
Gravitating Waves. Chase..... 344, 420
Heating Power of Coals. Cresson..... 175
Ichthyology of Utah. Cope..... 129
Indian Sculpture at Bald-friar..... 13
Indian Tribes of Costa Rica. Gabb..... 483
Iron and Steel Under Magnetism. Cresson..... 603
Langdale (W. Va.) Coal Land Model..... 177
Languages of Costa Rica. Gabb..... 483
Latent Heat of Meteors. B. V. Marsh..... 114
Lepidopteræ of North America. Grote..... 189
Lignitic Beds of the West..... 187, 447
Limonites of York County. Frazer..... 364, 370, 433
Lunar Monthly Rainfall. Chase..... 416–418
Magnetic Forces. Chase..... 612

Page.
Magnetism on the Strength of Iron 603
Mammoth Coal Bed 175
Map of the Schuylkill Water Gap 300
Mesozoic Traps. Frazer 402
Metal-Spectra. Outenbridge 162
Meteorological Observations on the Nile 632
Meteorology ..... Blodget, 439; Briggs, 641
Meteorology of New England. Channing 154
Meteors, Latent Heat. B. V. Marsh 114
Microscopic Sections of Trap. Dana 430, 432
Miocene Vertebrata. Cope 361
Moon's Color. Frazer 2, 155
Moraine at West Philadelphia. Hall 633, 644
New Mexico. Extinct Race. Cope 475
Nile, Meteorological Observations 632
Orton's Expedition to the Amazon 648
Pah-Ute Cremation 191
Papyrus *Shai-n-sinsin*, for sale 182
Peach Belt Movement. Emerson 175
Peale's Collection of Indian Relics 174
Perowskite in Arkansas. König 640
Philadelphia Geology. Lesley 436
Philadelphia Glaciers 633, 644
Phosphorus, Allotropic Form 108
Photographs 13, 174, 298
Plagopterinæ. Cope 129
Pœbrotherium (Leidy). Cope 110
Port Clinton Fault. Chance 183, 200
Rainfall. Chase 416, 614
Retort. Frazer 419
Rhynchophora of North America 649
Saving Fund Life Insurance 148
Shai-n-sinsin Papyrus 182
Signal Service Maps 175, 640
Somerset County Coals. Fulton 157
Spain's Population, &c. Delmar 301, 344, 422
Spruce Creek Geology. Lesley 19, 83
Symborodon Trigonoceras 2
Tartronic and Glyceric Acids. Sadtler 615
Tellurium and Bismuth Minerals. Genth 181, 636
Thermo-electric Currents. Cresson 440
Transit of Venus. Goodfellow 191
Transit of Venus. Davidson 423, 326
Trap. Frazer. Dana 402, 414, 430, 436
Tyndall's Address. Frazer 420
Tyrone Fault. Lesley 3
Vernier. Harger's 647
Vertical Lantern Galvanometer. Barker 440, 445
Walrus from Accomac Harbour 17
Warrior Mark Valley Geology 3, 19-83
Water Gap Glacier. Hall 620
Welsh's Copy of Franklin Picture 433
York County Limonites and Traps 364, 370, 402, 433
Zoology of a Pool in Colorado. Cope 139

CONTENTS—CONTINUED.

PAGE.

Stated Meeting, November 5, 1875. Mr. Hall exhibited Glacial Boulders from West Philadelphia. Mr. John Harger's Improvement in Vernier Arcs. Recommendation to Congress of Prof. Orton's Amazon Expedition..... 646

Stated Meeting, November 19, 1875. Bequest of Mrs. Peale; letter of Mr. Patterson, Executor; deposit of the Peale Collection. Increase of the edition of the Proceedings..... 648

On further Dynamic Co-ordinations, by Pliny Earle Chase..... 651

Stated Meeting, December 3, 1875..... 659

Report of Mr. Price on the Michaux Fund..... 660

Stated Meeting, December 17, 1875..... 662

On Dr. Valentini's Interpretation of the Mexican Calendar Stone, by Dr. Brinton..... 663

On the Ornamentation of the Public Buildings, by Mr. Walter..... 665

On the Influence of the Air on Life, and its connection with Meteorology, by Mr. Blazius..... 667

Index..... 675